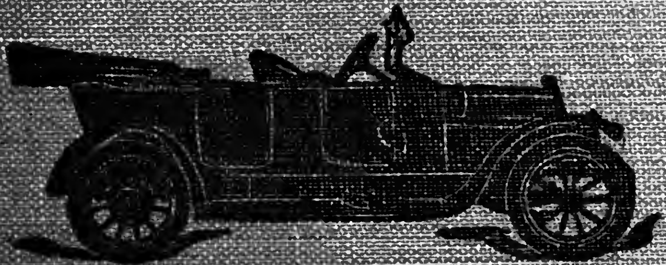
ARE OF
UTOMOBILES

B. EDWARDS



Care of Automobiles.

By J. B. EDWARDS.

Cincinnati, Ohio:
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FOREWORD.

THERE are so many angles to the modern automobile, so many distinct systems combined to make up the complete perfected car, that he is a broad man indeed, and truly worthy of the title "Automobile Expert" who is perfectly familiar with all of the various phases of motor car construction, care and repair.

Feeling that this is the case, and realizing that he is not of the broad stock that can grasp fully each of many fine points that have to do with the proper care of the automobile, the editor has in the present work, sought out from the current trade press the most apt of the many special articles on various phases of motor car care, each written by an expert in his one particular branch of the subject. The editor has confined his efforts to weaving the assembled matter into a composite whole that covers fully the broad subject in hand.

Not all of these specialists, highly trained as they are, are gifted with the knack of presenting highly technical matter in a manner that is not only perfectly understandable, but at the same time interest impelling, to the average non-technical car owner; nor were the original articles all handled from the same viewpoint. The editor's work, therefore, has consisted chiefly in redrafting the material supplied by these specialists the

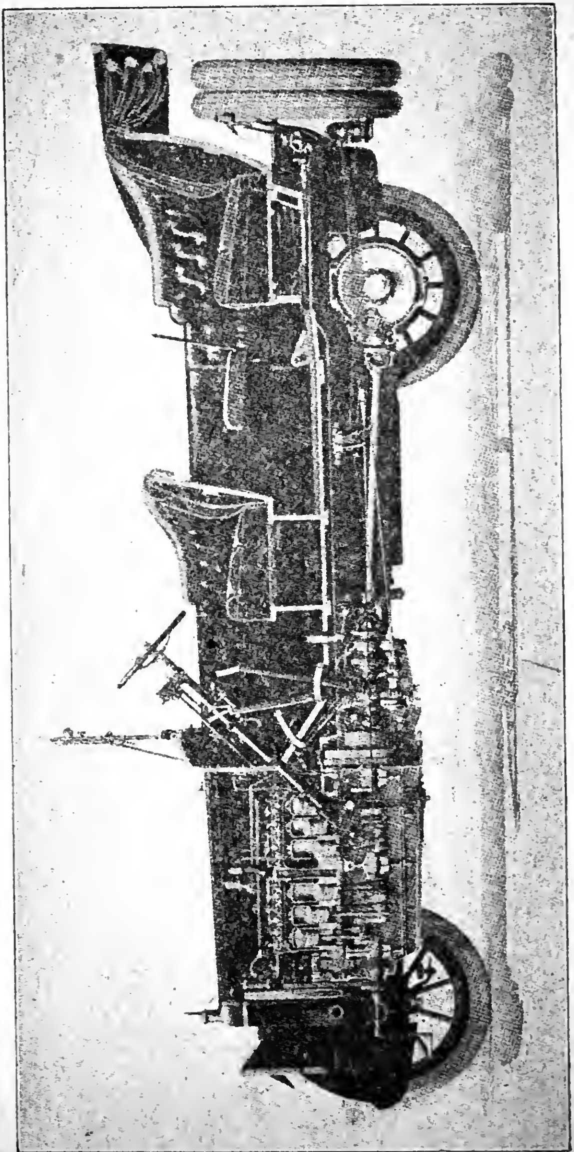
better to suit it for his present needs, and in arranging the matter in some sort of logical coherent shape so that the reader will not feel that he is starting a new book with the beginning of each chapter.

If, then, the reader finds that the style changes from chapter to chapter; if one subject is treated in a light, almost flippant manner, and the next in a ponderous, deep style, be happy in the knowledge that each article is authoritive, representing a deal of forethought by a specialist in his subject. What is lost in literary style is fully compensated for in the truthfulness and reliability of the subject matter.

One theorist, perhaps, with a gift for presenting his theories in readable style, could present a far more readable work; but for real value it never could compare with the efforts of the dozen or more specialists whose combined efforts have resulted in the present work.

One more word: In this, the third edition of the work, the chief efforts of the revisor have been directed to the task of bringing the volume right up to the minute. He has spared no effort necessary to give his readers first-hand information on the very latest practice—information that is not covered by any other motor book.

J. B. Edwards.



LAYING BARE THE WORKINGS OF THE MODERN CAR.

CROSS-SECTIONAL VIEW OF THE PACKARD "TWIN SIX."

Here is an illuminating picture originated by the Packard Motor Car Co. to throw light on the inner workings of the Twin Six chassis. It discloses the interior of the gearset crankcase and one block of cylinders. At the front end, just inside the crankcase, can be seen the silent chain which drives the camshaft. The sectional view of one of the cylinder blocks shows the small size of pistons and the adjustment of connecting rods. Careful scrutiny will reveal part of the lubricating system, which is a force-feed arrangement. At the rear end of the crankshaft may be seen the flywheel teeth, which engage with the self-starter gear. The self-starter heel button can be seen protruding through the floor boards. The clutch and gearset are housed in an extension of the crankcase, making a compact unit power plant. The driveshaft is of good length, which lessens the wear on the universals. Part of the spiral-bevel gear has been cut away, in the picture, to show the pinion which engages with it in the final drive. The Twin Six is driven through new type springs. This is shown in the illustration.

CHAPTER I.

A Word on the Automobile Engine.

Heat the Real Source of Its Energy—How the Heat is Generated and Disposed of—Various Types of Modern Motors Described and Discussed.

A MOTOR CAR involves a considerable outlay of money, and for that reason purchase should be made *intelligently.* The buyer should know exactly why he makes a particular choice. He should not take the salesman's word alone. On the contrary, he should be able to tell, of his own *knowledge,* whether the salesman speaks from conviction, or merely from enthusiasm.

Of first importance, then, the buyer should understand that an automobile motor is by far the most important part of a motor car, and that the whole question of the car's worth depends upon its motor. Next in importance, the buyer should understand that all automobile motors are *heat* engines. Regardless of their form of construction, or their number of cylinders, all automobile motors are heat engines. By that it is meant that heat is the force which furnishes the power of the motors. To reach an understanding of automobile motors it is first necessary to get this fundamental fact firmly fixed in mind.

Gasoline is the fuel which supplies the heat. In other words, gasoline is the "raw material" for making the *heat,* just as cotton is the raw material for making cloth.

When the gasoline is taken into the carburetor it is mixed with air and vaporized. That is, it is transformed into gas. This gas is then taken into the cylinders, and by means of an electric

spark it is burned, or, as we generally say, it is "exploded." Gasoline vapor burns so very quickly that we speak of the transformation as an "explosion." If you could burn a stick of stovewood or a lump of coal as quickly as you can a quantity of gasoline, they, too, would "explode."

This burning, or "exploding" of the gasoline, creates a very high degree of *heat*—about 2500 degrees Fahrenheit. Heat, as everyone knows, expands, thus if we heat a length of metal rod, the rod expands and the amount of expansion depends directly, within certain limits, on the degree of temperature to which the metal is heated. Similarly, if we heat a quantity of air or other gas, it expands according to the amount of heat applied. When, therefore, the charge is exploded in the gas-charged cylinder of the engine, the gas is expanded considerably and it is the action of this expanding gas against the top of the piston which drives it down; and the piston being connected to the crankshaft causes that part to rotate and this rotation in turn is transmitted to the road wheels. It is then, after all, nothing but heat which causes the automobile to move.

At the end of the power stroke a considerable portion of the 2500 degrees of *heat* derived from that charge of gasoline is gone, used up in the effort necessary to drive the piston downward.

Still more of it was carried out of the cylinder with the exhaust gases when the exhaust valve was opened at the bottom of the piston stroke and the remainder was lost by radiation through the cylinder walls whence it is carried away by the cooling water. In the typical automobile motor about 25 per cent of the available heat of the fuel is used in driving the piston, the remainder being lost through the exhaust and

the cylinder walls. And of the 25 per cent that is converted into useful work, another fifth is lost through friction in the mechanism itself, so that, roughly, only about 20 per cent of the power actually available in the gasoline is utilized to drive the car forward.

Valve-in-Head or I-Head Type of Motor.

"T"-Head Type of Engine.

When the piston has reached the bottom of its stroke, a valve is opened which permits the spent gases to escape from the cylinder into the muffler and thence to the atmosphere. This valve, which is actuated by a cam mounted on a camshaft which is driven at half the crankshaft speed, is kept open until the piston has again reached the top of its stroke when it closes and another valve, the inlet valve, is opened by another cam mounted on the same shaft. This

second valve opens a passage from the carburetor to the cylinder and is kept open until the piston reaches the bottom of the stroke again, the piston in the meantime sucking in a charge of the vaporized gasoline, much the same as a medical syringe will suck up a quantity of liquid when the plunger is pulled out.

When the bottom of the stroke is again reached the inlet valve is closed and there being no further communication with the air, the gas contained in the cylinder is compressed by the ascending piston, to be ignited by the spark when the piston has nearly reached the top of its stroke. The cycle is then repeated and the engine operates so long as gasoline is supplied to the carburetor and a spark is produced at the plug points at the proper interval to insure ignition.

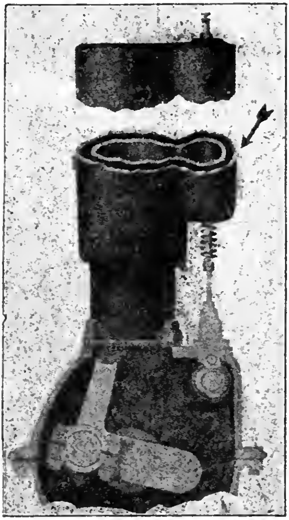
So far, all automobile motors are alike; for all modern automobile engines operate on the "four-cycle" or Otto cycle principle. Time was when a different type of motor, operating on what is known as the "two-cycle" principle was used by a few manufacturers, but that type never proved wholly satisfactory in motor car service.

Aside from the number of cylinders, the most distinctive features characterizing modern automobile motors is the valve arrangement.

For the most part, automobile manufacturers have preferred to stick to the "poppet" valve motor; that is a motor with valves shaped like a mushroom, with a conical face ground to fit a recessed face formed for the purpose in the combustion chamber of the motor. Only one other valve arrangement has made any considerable progress in this country, and that is the Knight motor with the valve operations carried out by a pair of sliding sleeves mounted concentric with the piston and given a vertical movement which causes them to cover and uncover suitable ports

in the cylinder walls at the proper time by means of an eccentric carried on a half time shaft.

The poppet valve motors are divided into four distinct classes, according to the valve arrangement, although at the present time only three of these classes are in general use in the automobile field. Of the three, one, the T-head type, is fast losing ground. The four classes are known respectively as the T-head type; L-head type;



"L"-Head Type of Motor.

I-head or "valve-in-the-head" type and F-head type.

The T-head type, which when four cylinder motors first began to grow in popularity, was far and away the most generally used, has the inlet valve of each cylinder mounted on one side of the motor and the exhaust valve on the other side so that the cylinder casting, as can plainly

be seen in the accompanying diagram, resembles roughly a capital "T." The complication of the arrangement has been the chief cause of its abandonment, for it involves not only the use of two camshafts, one at either side of the motor, but also the use of double valve pockets. Doubling of the pockets entails added complication in the casting of the cylinders, and also affords a greater area of exposed surface in the combustion chamber which in turn entails larger heat losses through radiation. It moreover results in a design that does not lend itself readily to cleancut appearance which the modern motorist demands in his car.

The L-head type of motor, on the other hand, with both valves on the one side of the cylinder so that the cylinder casting resembles the letter "L" avoids the duplication of the camshaft and valve pockets and lends itself readily to full enclosure of the valve mechanism giving rise tc a cleaner cut motor, as to appearance. It has the additional advantage that the cool incoming gases tend to keep the exhaust valve at a moderate temperature and help in a measure, at least, to keep the valves from pitting and burning. It is far and away the simplest of the four arrangements and as a matter of course, is the one which is used by the majority of present day manufacturers.

The I-head type of motor is without valve pockets, both valves being positioned in the head of the motor as shown by the accompanying illustration. This design has certain virtues all of its own; also certain disadvantages, although drawbacks do not offset the advantages accruing to the type. Certain it is that the valve arrangement permits of doing away with the pockets, reducing the area through which radiation can take place and making for increased speed of

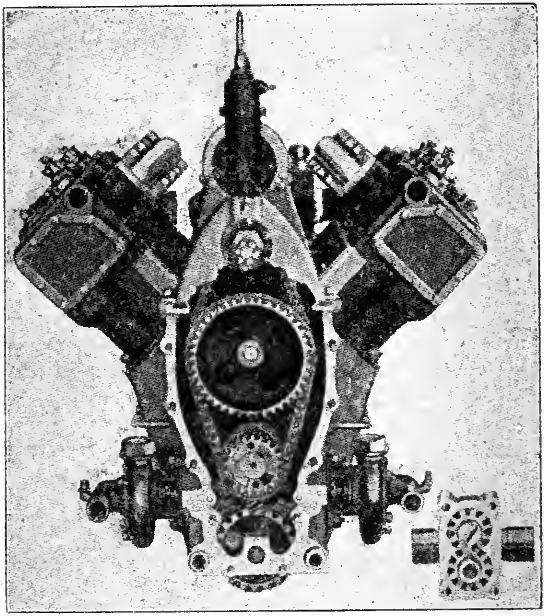
flame propagation which spells increased power. On the other hand, the valve mechanism itself is more complicated, involving the use of overhead rockers and long push rods. It is also a hard type to enclose. Much progress has been made by the "valve-in-head" engine over the past five years. Present types are fully enclosed, valve parts well lubricated and comparatively quiet.

The F-head motor is rarely met with in automobile practice although until lately it has been used almost universally in motorcycle motors. It comprises an inlet valve mounted in a valve pocket directly over the exhaust valve and is a cross between the L-head motor and the "valve-in-the-head" type. Its principal advantage accrues from the fact that larger diameter valves can be used than with either the I-head type or the L-head type and a corresponding increase in power can, theoretically, be counted upon for this reason. It is a cool-running type, not oversensitive to carbon deposit, and is finding wide application on modern cars.

As has been amply set forth, each type of motor has its own peculiar little advantages so that it is a hard matter even for the expert to decide which type is the best; a great deal depends upon the service to which the car is to be put and the type of man who is to operate it. For the speed-fiend, for instance, or the man who puts gasoline economy above every other feature, the valve-in-the-head motor undoubtedly will not prove disappointing; on the other hand, for the slow careful driver who is looking principally for comfort and lack of complication, the L-head type with its interchangeable valves, easily adjusted, will be found best suited to his purposes.

The present eight-cylinder engine is built in what is termed V-form, the cylinders being arranged in two sets of four each, which make an

angle of 90 degrees to each other and outline the letter V. The V-type engine presents a very moderate length, resulting in a somewhat shorter hood than would be necessary with a six-cylinder engine of the same power, and also a somewhat roomier body with the same wheel base.



Front View of the Cadillac Eight-Cylinder V Engine.

Makers of eight-cylinder engines claim that they exceed the six-cylinder in flexibility, uniformity of torque and freedom from vibration and even if equalled in power they possess the same economy, easy turning length and light weight as in the light four. Power for power the eight seems to possess quite an advantage over the six

in the above respects. They are very smooth in operation, as there are very little lapses during impulses, eliminating the laboring jerks and jars. In an engine of this type there are eight power strokes in two revolutions, or four in one revolution of the crank shaft, or one explosion every 90 degrees of crank shaft movement. Each explosion is smaller than in a six-cylinder engine and as the crank shaft is shorter and has fewer arms the annoying crankshaft vibrations are eliminated.

There is another advantage possessed by this type of engine of which very little has been mentioned, and this is in respect to self-starting. Roughly speaking, an engine of this type need have but half the piston area of a four of equal stroke and power. Therefore, the starting motor must overcome a compression resistance that is about half that encountered in the four-cylinder engine, tending to reduce the size of and consumption of the starting motor and also to reduce those difficulties which pertain to the efficiency of a single unit starting and lighting system.

Opinions differ as to the best method of attaching and connecting rods and one finds two methods in vogue. They are either placed side by side or one is forked and the other operates on a bushing within the fork of the former. There are also two camshaft constructions, one having eight cams and the other sixteen, while the valves may either be operated direct or through rocker arms. With the connecting rods placed side by side it is necessary to stagger the cylinders to center them with the connecting rods.

Lubrication seems to present another problem as this seems to be divided between pressure feed and splash, and combinations of both. Both forced and thermo syphon cooling systems are also used, while with the former opinions also

vary as to whether one or two pumps should be used. In some cases the intake manifold is water-jacketed, while the manifolds are almost universally placed on the inside of the V.

So much for the eight-cylinder engine. Its development during the past five years has been most rapid and to date there are no less than a dozen different makes of eight-cylinder engines and a score or more of cars powered with them. Among the best known of the motors are the Buda, Perkins, Ferro, Ross, Herschell-Spillman, Jenks, Davis and Stearns. Of these by far the greater number do not differ materially from Cadillac and King practice, although detail cylinder motor, that there is not at least one cylinder turning the crankshaft. Before one cylinder is completely out, the next in firing order has fired and carried on the work.

Just as the eight uses a standard shape of four-cylinder crankshaft, so does the twelve or "twin six" employ the familiar type of six-cylinder crankshaft with its throws set at angles of 120 degrees. This difference in crank angle, however, makes it advisable to set the opposite blocks of cylinders at an angle of 60 degrees instead of the 90 degrees angle usually found in the eight. The twelve is thus inherently a narrower motor than the eight and this feature presents several interesting points in its favor The sharper angle between the cylinder blocks permits the motor accessories, such as the magneto, carburetor, water pump, electric starter and dynamo, to be placed in convenient locations outside of the "V" and thus leaves the space between the cylinder blocks clear for free inspection, adjustment and grinding of the valves. The usual practice with the eight, on the other hand, is to crowd the "V" with these necessary accessories, rendering the valves, when operated from a single camshaft,

quite inaccessible.

Furthermore, the narrower motor permits of the use of a more accessible steering gear and allows the frame to be narrowed so that the radius required for turning is reduced by a considerable amount. And then, because for a given power motor, the cylinders in each block of a twelve motor are smaller than in a six, each impulse imparts less strain to the crankshaft, which, therefore, can be made lighter and a single center bearing is generally found adequate.

In its structural features, aside from those which have been brought to the attention of the reader, the twelve does not vary materially from the more common eight.

CHAPTER II.

The 16-Valve Motor and the Knight Type.

NOW comes another valve arrangement—an idea, by the way, which the motor car designer has taken from the designer of high speed motorcycles—the "duplicate valve motor." That is to say, a motor with two inlet valves and two exhaust valves for each cylinder, so that in the four-cylinder motor there are sixteen valves in all instead of the customary eight valves, and in the six-cylinder engine of duplicate valve design there are, of course, twenty-four valves in all.

It has long been a recognized fact that the efficiency of any motor depends upon two features more than any others—the size of the valve opening and the speed with which the valves close after the intake and exhaust strokes. Using single intake and exhaust valves, their diameters are necessarily restricted by the diameter of the cylinders, and it has been found impossible to fit valves sufficiently large to permit of absolutely free ingress and egress of the gases. Another drawback of the single valve arrangement is the fact that increasing the diameter of the valve in order to permit of freer passage of the gases increases the tendency to warp to a marked degree, and to counteract this the valve heads have to be made correspondingly heavy; a fact which not only makes for increased wear and tear on the whole valve mechanism, but also for sluggish action and noise.

The adoption of double valves eliminates these difficulties at one sweep. For instance, two inlet and two exhaust valves in the case of a typical 16-valve four-cylinder motor give a valve opening 50 per cent greater than in the

case of the single valve arrangement, the valves in the duplicate arrangement each being of moderate diameter and weight. Quite naturally, their light weight springs permit of instantaneous, snappy action, which is one of the characteristics of the sixteen-valve motor.

Having, by means of this special valve arrangement, done away with much of the throttling of the gases common to the more orthodox type, it is logical to expect a more efficient motor, each intake stroke drawing in a full charge of clean, combustible vapor, and each exhaust stroke expelling every last atom of the spent charge from the swept volume, leaving the cylinders approximately clean for the next charge.

The result is a motor as nearly 100 per cent efficient as the ingenuity of man has been able to devise. It exceeds in flexibility the average multi-cylinder motor, and is unequaled in swift acceleration and smooth operation, while at the same time retaining the economy and reliability which have always been the cardinal features of the four-cylinder design.

It is needless, perhaps, to add that this type of motor has been thoroughly tried out, having run the speed gamut and been found not lacking in the attributes that make for speed as well as stamina and reliability. While, as was before pointed out, the duplicate valve system is in reality an adaptation of the ideas that have made the American motor cycle preeminently the fastest two-wheeled vehicle in the world, the valve arrangement as applied to the car motor was first seen here on the Peugeot racing machine which came over and took the laurels on practically all of the American speedways a couple of years ago. The development of the type by Stutz, White, Drexel and Pierce-Arrow is directly trace-

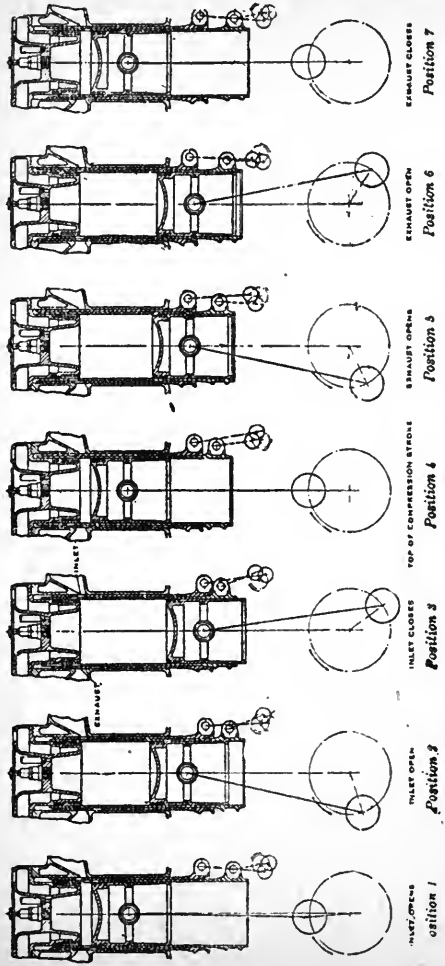
able to the good showing made by the French machines at that time.

The good old poppet valve motor has stood the test of time and has become so firmly intrenched in the hearts of motorists everywhere that it is doubtful if it ever will be displaced. Three or four years ago, following the successful introduction of the Knight sleeve valve motor, there was a veritable flood of motors in which the poppet valve was displaced by valves either of the sleeve, rotary or piston type; but with the exception of the Knight motor alone, none of these has withstood the test of time.

In the Knight engine the valve functions are performed by two ported sleeves, one within the other, which are interposed between the piston and the cylinder wall, the clearance between the sleeves, the wall and the piston being very slight.

These two sleeves, which replace the valves, are reciprocated by means of an eccentric shaft. This shaft, in the case of the four-cylinder motor, carries eight eccentrics, each eccentric operating one of the eight sleeves through the intermediary of short connecting rods or links. The detachable head of the cylinder is made of special design, as is plainly indicated in the cross-sectional view, to permit of the sleeves sliding up past the combustion chamber and effecting an efficient gas seal.

The movement of the two sleeves, which control the flow of the gases to and from the cylinder, may be described as follows: Referring to the plate which represents the timing of the Stearns-Knight four-cylinder engine, Position 1 shows the inlet starting to open, while No. 2 shows the inlet fully open, in this case the outer sleeve has moved downward and the inner sleeve upward until the ports in both coincide with the cylinder port. Position 3 shows the inlet clos-



Inlet and Exhaust Timing Diagram of Stearns-Knight Motor.

ing, and 4 the top of the compression stroke. Position 5 shows the end of the power stroke and the exhaust valve beginning to open. Here the sleeves again shift to bring the ports in line, this time, however, on the opposite side of the combustion chamber.

The claims for the Knight motor are not only absolute silence, due to the absence of tappet and valve action noises, but absolute precision in valve timing, freedom from valve pitting, warping and sticking, and less wear and tear coupled with the absence of valve pockets and consequent greater power for the same bore and stroke.

CHAPTER III.

Horse-power—Its Definition and Determination.

Just What is Meant by the Term as Applied to Any Prime Mover and Why Its Exact Determination is Difficult—Modern Testing Practice —The Use of Horse-power Formulae.

WHAT is horse-power? This question, while well understood by engineers in general, is a hard problem for the beginner to grasp. Horse-power provides a never failing source of discussion for him. No other term in his vocabulary is so misunderstood, or has so many interpretations, and at the same time it is a subject of vital importance to him, for the reason that it affects his comfort, his pride or his bank account.

The purpose of this article will be to enlighten him on this subject and at the same time show how the horse-power of an automobile engine can be approximated very closely by the S. A. E. formula, giving an example as well as a table. The table comprises cylinder diameters of 2¼ to 6 and engines having 1, 2, 4, 6 or 8 cylinders. No mathematical data is used, to avoid complications.

The definition of the word "horse-power" as applied to a motor car engine is not understood by the average automobile owner or driver. There are many laymen who think that by horse-power is meant the average load which a horse can pull in continued service. This is not true, however, as the pulling power of horses varies and no definite point could be reached in this way. It is evident that a large horse is capable of pulling a

greater load in continued service than a smaller animal.

The term "horse-power" was first used by James Watt, after numerous tests of the load which the average horse could pull in continued service and a constant derived therefrom, which will be discussed later.

Horse-power as a technical term has a very definite meaning. It is defined as the rate of doing work. Work, in turn, is the product of a force and the distance it moves. Thus horse-power is force times distance divided by time. It is expressed in units implying these three quantities: pounds, per foot, per minute. One horse-power is equivalent to 33,000 foot pounds per minute, that is, a power which can lift 33,000 pounds one foot in one minute, or 1,000 pounds 33 feet in one minute, or 1 pound 33,000 feet in one minute, or 1 pound one foot in 1/550 second.

In a motor car engine power is developed by the burning and consequent expansion of the gasoline mixture in the combustion chamber. The expansion results in a force exerted on the piston head, the travel of the piston on its stroke gives the distance, and the number of revolutions per minute of the crankshaft adds the time factor. Given the pressure in pounds per square inch on the cylinder, the stroke in feet or inches, and the number of revolutions per minute; the horse-power developed in a gasoline motor can easily be computed. Although the last two quantities are easy enough to obtain, the first, unfortunately, cannot be had without the use of delicate and costly instruments.

To determine the power actually developed by a motor, numerous methods can be used, but all depend upon the absorption and incidental measurement of the power, as by a friction brake, electric generator, a water pump or fan. As the

earliest and best known of these the friction or prony brake method may be described. Like all others it depends upon the definition of force times distance divided by time. The application is generally quite familiar. A brake band or shoe is applied to the fly-wheel and prevented from rotating with the fly-wheel by weights attached to the end of the lever arm attached to the brake band. The weight or the length of the lever arm is adjusted until the weight is in equilibrium, tending neither to rotate with the fly-wheel or to drop under the force of gravity. The weight then gives the force, the length of the arm the distance, and the number of revolutions the time factor, necessary for calculating the horse-power.

In many automobile plants where motors are made in large quantities, the run in test is regarded as a necessity and it is a simple expedient to attach a fan to the fly-wheel in place of the clutch, and, if the fan is properly devised, it will limit the speed of the motor to that which should obtain in actual service, when the motor is doing its accustomed work. The fan requires no attention; it offers a constant resistance, so long as the speed of the motor is maintained constant, and if the speed changes do creep in they will indicate that some adjustment is necessary to either mixture or ignition system, but there will be no damage done, even if the adjustments are not made. This form of dynamometer is economical; it takes up almost no added space, and it is, in first cost, at the bottom of the list. In some instances this fan dynamometer has been fitted with a tachometer or speed indicator, by means of which the power delivered may be noted by ascertaining the speed and comparing it with a chart of power for speed as determined by previous calibration.

In large automobile factories the balanced electric system seems to have considerable advantage. There may be a number of sets of these machines, and all that is required to satisfy conditions is to have the machines in pairs. One machine (of each pair) is driven by an engine as a dynamo, which furnishes current to the other, which as a motor drives the second engine which is getting its "run in" test. The dynamo loads the engine which furnishes the power, which is electrically transmitted to drive the second engine, which is being run in during this period of time.

There is still another possibility. If the engine to test is connected to a centrifugal pump and the pump in turn by piping to a reservoir, the power required to pump the water to the reservoir may be adjusted to equal the ability of the motor to be tested and the work done in the process turned to good account.

It should be understood that the motor testing question has other angles besides the one which is being considered here; investigations of the internal conditions are also taken into account.

Obtaining the cylinder pressure in pounds per square inch, that is, the force exerted upon the piston by the expansion of the gas, unfortunately cannot be obtained without the use of delicate and costly instruments, as mentioned above. For this reason a formula was adopted by the Society of Automotive Engineers which is termed the S. A. E. formula, and which was intended to approzimate the horse-power of automobile engines very closely. This formula received such a favorable reception by both manufacturer and user that its continued use has been assured. Before its appearance there had been a long-felt need of some connecting link between the size and probable capacity of the various

motors. Most objections to this formula are based upon the idea that it is to determine once and for all the power which a given motor is capable of developing. This is not true, as the horse-power of a gasoline engine cannot be computed exactly from its dimensions by any formula whatsoever, no matter how intricate and learned in appearance.

The principal feature considered in this formula is simplicity, and this is an unquestionable advantage. It would be impossible to simplify it any further and still obtain the least approach to the horse-power rating. There is, however, one short cut, which might not appear to the use. For instance, the formula reads: H. P. $= \frac{D^2N}{2.5}$ which in reality is the same and equal to H. P. $=$ .4 D^2N, as will be explained later.

In the formula—

D = Diameter of cylinder in inches.

N = Number of cylinders.

2.5 is a constant based upon a mean effective pressure of 70 pounds per square in. and a piston speed of 1,000 ft. per min.

D^2 is read as the diameter squared, and to square any number is to multiply it by itself; that is to say, the square of 2 is equal to $2 \times 2 = 4$, or $4 \times 4 = 16$, or $16 \times 16 = 256$. Likewise any number multiplied by itself will give the square of that number.

In using the formula, remembering that the power of a motor is in proportion to the square of the cylinder diameter, the formula may be written as follows:

Horse-power = Diameter of cylinder in inches squared, multiplied by the number of cylinders contained on the engine and divided by the constant 2.5; or to transpose the formula. Horse-power = .4 times the diameter of cylinder in

inches squared, multiplied by the number of cylinders.

Citing, for example, a four-cylinder motor with a cylinder diameter of four inches, and proceed to calculate the horse-power of the engine.

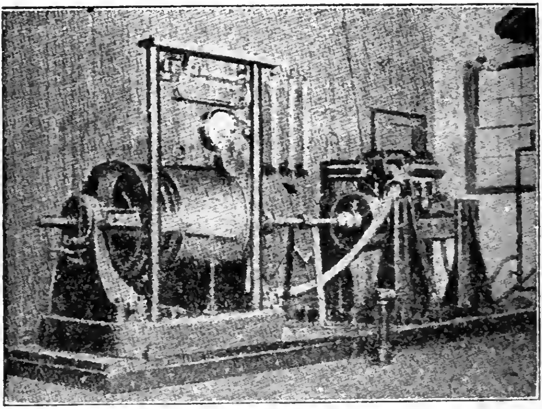
$$\text{H. P.} = \frac{4 \times 4 \times 4}{2.5} = 25.6 \text{ or } .4 \times 4 \times 4 \times 4 = 25.6$$

For six cylinders, four-inch cylinder diameter—

$$\text{H. P.} = \frac{4 \times 4 \times 6}{2.5} = 38.4 \text{ or } .4 \times 4 \times 4 \times 6 = 38.4$$

And again for an eight-cylinder engine—

$$\text{H. P.} = \frac{4 \times 4 \times 8}{2.5} = 51.2 \text{ or } .4 \times 4 \times 4 \times 8 = 51.2$$



A Typical Automobile Motor Testing Stand.

Using precisely the same method the horse-power of any motor (according to this empirical formula) may be approximated. Still further convenience may be had by the use of a table such as the accompanying one, especially for fractional values of the bore. This table is in the main self-explanatory, but a few features may be pointed out. The values are given so close together that intermediate values may be found by interpolation. Thus $4^1/_{16}$-inch is half-way be-

S.A.E. HORSE-POWER TABLE.

BORE	CYLINDERS					
	1	2	4	6	8	12
2¼	2.02	4.03	8.10	12.15	16.20	24.30
2⅜	2.25	4.51	9.02	13.52	18.05	27.07
2½	2.50	5.00	10.00	15.00	20.00	30.00
2⅝	2.83	5.66	11.23	16.85	22.41	33.64
2¾	3.02	6.04	12.08	18.13	24.16	36.24
2⅞	3.34	6.68	13.37	20.00	26.74	40.11
3.0	3.60	7.20	14.40	21.60	28.80	43.20
3⅛	3.91	7.82	15.64	23.50	31.28	46.92
3¼	4.23	8.46	16.92	25.39	33.84	50.81
3⅜	4.57	9.10	18.21	27.30	36.42	54.63
3½	4.90	9.80	19.61	29.45	39.22	58.83
3⅝	5.27	10.54	21.08	31.57	42.16	63.24
3¾	5.62	11.25	22.50	33.75	45.00	67.50
3⅞	6.05	12.11	24.22	36.32	48.44	72.66
4.0	6.40	12.80	25.60	38.40	51.20	76.80
4⅛	6.80	13.60	27.20	40.80	54.40	81.60
4¼	7.25	14.50	29.00	43.50	58.00	87.00
4⅜	7.66	15.32	30.65	46.00	61.30	91.95
4½	8.10	16.20	32.40	48.60	64.80	97.20
4⅝	8.57	17.14	34.28	51.41	68.56	102.84
4¾	9.03	18.07	36.15	54.20	72.30	108.45
4⅞	9.56	19.12	38.25	57.21	76.50	114.75
5.0	10.00	20.00	40.00	60.00	80.00	120.00
5⅛	10.55	21.10	42.20	63.20	84.20	126.40
5¼	11.05	22.10	44.20	66.40	88.40	132.60
5⅜	11.58	23.17	46.34	69.50	92.68	139.02
5½	12.12	24.24	48.48	72.72	96.96	145.44
5⅝	12.70	25.40	50.80	76.10	101.60	152.40
5¾	13.25	26.50	53.00	79.50	106.00	159.00
5⅞	13.81	27.63	55.28	82.88	110.56	165.88
6.0	14.40	28.85	57.70	84.64	115.40	173.10

tween 4 and $4\frac{1}{8}$, and consequently the power of a $4\frac{1}{16}$-inch four-cylinder motor is between that of a 4 and $4\frac{1}{8}$-inch motor.

For example, we will take these three cylinder diameters in order to show the interpolation is carried out. We must first find the difference between the 4 and $4\frac{1}{8}$-inch motors. Referring to the table, a $4\frac{1}{8}$-inch four-cylinder motor is rated at 27.20 H. P., while the 4-inch is rated at 25.60 H. P. Now, subtracting this from the former, we get 1.60 H. P. Half of this sum added to the power of the 4-inch motor will give us the power of $4\frac{1}{16}$-inch motor, thus: $1.60 \div 2 + 25.60 = 26.40$ H. P. In precisely the same manner any other size in between those listed can be found.

As horse-power by this formula is proportional to the square of the cylinder diameter, doubling this multiplies by four and halving it divides by four. Applying this to the table, the power of a two-inch cylinder will be one-fourth of the power of a four-inch cylinder, and the power of a seven-inch cylinder will be four times that of a $3\frac{1}{2}$ or 19.60 H. P.

As a final criticism of the formula, and a warning against its too confident use, it will suffice to mention that it tends to overrate small motors and underrate large motors. This really makes very little difference, for no one is interested in a close comparison of a three-inch and a six-inch motor, as he is of one more nearly the same size and within the variation of an inch or so in the diameter, the formula is reasonably accurate. Empirical formula will avail up to a certain point and within certain explored limits. In a motor, for illustration, the formula will work very well indeed if the cylinder diameter is within the domain found to conform to the conditions which rendered the formula possible.

CHAPTER IV.

The Fuel Feed and the Carburetor.

Various Methods of Conducting Gasoline From Tank to Motor—Carburetion in Theory and Practice.

THE office of the carburetor is that of changing liquid gasoline into an explosive mixture, and the function of this is to bring a quantity of air in contact with a spray of gasoline in correct proportion for complete combustion. The evaporation of the gasoline as it mixes with the air forms the explosive mixture which is introduced into the cylinders of the motor when the inlet valves open.

A carburetor, in order to handle a motor properly under all conditions, must supply a uniform mixture at all engine speeds, that is, at all points of the throttle opening. In other words, the carburetor must take raw gasoline and mix it with the proper amount of air under any condition demanded by the motor, and in performing this delicate task the carburetor must, of course, be adjusted carefully to give good results. If the engine were to run at a constant speed all the time this would be a very simple problem, providing the load did not vary.

Gasoline is carried in a tank located either in the body or at the rear end of the chassis. It is supplied to the carburetor by one of four methods in general use:

1. Gravity feed.
2. Pressure feed.
3. Combination of pressure and gravity feed.
4. Vacuum feed.

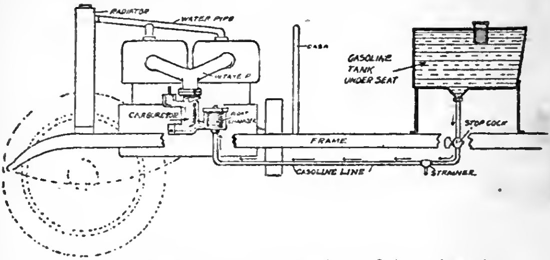


Fig. 1. Gravity Feed—Gasoline flows from tank to the Carburetor by gravity.

In the first system (Fig. 1) the tank is mounted considerably above the carburetor so that the gasoline will flow naturally. The tank may either be placed in the cowl of the body or under the front seats, if the carburetor is placed low enough to insure an easy flow.

In the pressure feed system (Fig. 2) the tank located at the rear of the chassis, and either the pressure of the exhaust or air pressure are used to force the gasoline to the carburetor.

The third system (Fig. 3) is a combination of the above types, having the tank located at the rear and an auxiliary tank located in the cowl or attached to the engine or dash under the hood. The gasoline is forced under pressure to the small tank from which it flows by gravity to the carburetor.

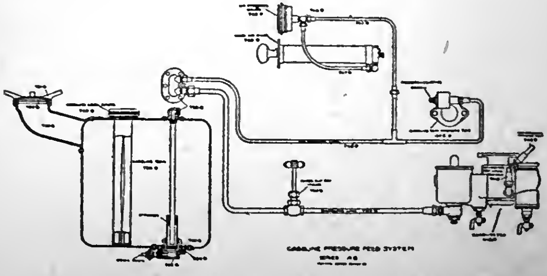


Fig. 2. Pressure Fuel Feed System.

In the vacuum feed system (Fig. 4) the main tank is located at the rear of the chassis, while the suction in the intake pipe is used to draw gasoline into a small tank on the engine, from which it flows by gravity to the carburetor.

This vaporization of raw gasoline may be accomplished in two ways, by heat or by vacuum; vaporization due to pressure reduction is distinguished from vaporization caused by heat. In the vacuum method vaporization is only partly complete, no matter how far the process of pressure reduction is carried, since that part of the fuel which vaporizes does so through the abstraction of heat from the remainder, which becomes constantly colder until finally the temperature is so low that vaporization ceases until heat is supplied from some outside source. When vaporization is brought about entirely by heat from an outside source, the degree to which it may be carried depends wholly on the amount of heat supplied, since the temperature of the liquid is being constantly raised to or maintained at the proper point.

In practice neither of the above principles are carried to the limit, but both act together.

The reduced pressure due to motor suction causes vaporization with a lowering of the temperature, and the heat of the air tends to cause vaporization through the transfer of heat from itself to the liquid. Each of these actions assist the other. The air supplying heat to the liquid as it cools by vaporization under reduced pressure and the reduction in temperature due to pressure reduction, facilitating the transfer of heat from the air to the liquid.

A carburetor consists of two parts, one termed the float chamber, or bowl, and the other the choke tube, or mixing chamber (Fig. 7). Gasoline from the main tank passes to the float cham-

ber (Fig. 7) through a needle valve and strainer which regulates the amount of gasoline entering the carburetor. The function of this float is to maintain a constant level of gasoline in its own chamber and the chamber in which the nozzle or jet is located. The choke tube accommodates this nozzle and allows a stream of air to pass around it when the piston is traveling downward on the suction stroke. When air rushes up around this nozzle, it draws with it a certain amount of sprayed gasoline, and the mixture of gasoline and air on the sides of the intake manifold becomes a gaseous mixture. A small butterfly valve located near the top of this choke tube and connected with the throttle lever on the steering wheel controls the amount of mixture entering the cylinders.

From what has been mentioned above, the readers should now understand the principle of carburetion and the action of the carburetor. A good portion of the carburetor troubles will be taken up in detail and may be listed in order of importance as follows:

1. Stoppage of gasoline supply.
2. Water in the gasoline.
3. Freezing of the carburetor.
4. Carburetor flooding.
5. Nozzle choked.
6. Excessive air temperature.
7. Carburetor adjustment.

The above troubles will be mentioned here to complete this subject.

1. Stoppage of the gasoline supply. This is due to empty tank, clogged supply pipe, air-bound supply pipe or leak in supply pipe, while in addition to this the flow may be stopped, due to the freezing of the carburetor and a sticking float. As mentioned previously, this can be de-

tected by trying to flood the carburetor, as sometimes this is caused by dirt which obstructs the filter gauge at the inlet to the float valve. If this does eliminate the trouble, be sure to examine the pipe connections and tank, as all leaks in the pressure system will cause a stoppage of gasoline flow, while an air-bound pipe will also do this in the gravity system. See that the filler cap vent hole is not clogged, as this causes the pipe to become air-bound in the gravity system. Leaking air joints in pressure system can be detected by putting a light mixture of soap and water over the various connections; if bubbles show, there is a leak. Tighten connections to prevent the escape of pressure.

2. Water in the gasoline is detected by the motor running and stopping and running in fits and starts. To determine if there is water in the gasoline, draw a small quantity from carburetor or sediment bulb on gasoline tank. Gasoline put into the tank should always be strained through a fine screen, which will separate this water. This fine screen will serve a double purpose, in catching any particles of dirt and excluding all water which the gasoline may contain.

3. Freezing of the carburetor is due to water settling in the float chamber or supply pipe in cold weather when the motor stands idle any length of time. If the temperature is cold enough, it will freeze. An application of rags saturated with hot water will remedy the trouble, after which drain float chamber and sediment chamber in the gasoline tank.

4. Flooding is caused by dirt, which prevents the float valve from seating, a defect in the float mechanism, which would prevent the float valve from seating, and a saturated cork or punctured metal float. A leaky float valve will also cause the carburetor to flood.

Dirt under the float valve is perhaps the greatest source of trouble when the carburetor floods, since this valve, through the action of the float, controls the amount of gasoline entering the float chamber. Some times a continued flooding will remove this dirt. However, the best method is to remove the float chamber, so that it can be thoroughly cleaned. In doing this the other things which cause flooding can also be inspected. Some part of the float mechanism may have become bent to prevent the valve from closing, while the valve and seat may need renewing.

The float should also be examined. If this is made of cork it may have become saturated with gasoline, so that it is too heavy to rise and return the valve to its seat. If it has become saturated, it should be thoroughly dried in a warm place for a number of hours, after which give it a thin coat of shellac to prevent resaturation. If it is made of metal, it may have sprung a leak, so that it becomes filled with gasoline. If this is the case, drill a small hole into it so that the gasoline can be drained out of it; finally solder the leak and the hole.

5. Nozzle choked. If the float chamber fills with gasoline, the nozzle or jet which is situated directly in the path of the incoming air may have become choked with dirt. However, this would only cause the engine to misfire once or twice, since the obstruction would soon be removed by suction of the engine.

6. Excess air temperature. Some carburetors have provisions for heating the fuel with both hot water, which is circulated around the mixing chamber, and hot air, which is taken from around the exhaust manifold and led into the primary air intake. Under ordinary circumstances these two devices should not be touched. However, in extremely hot climates it may be

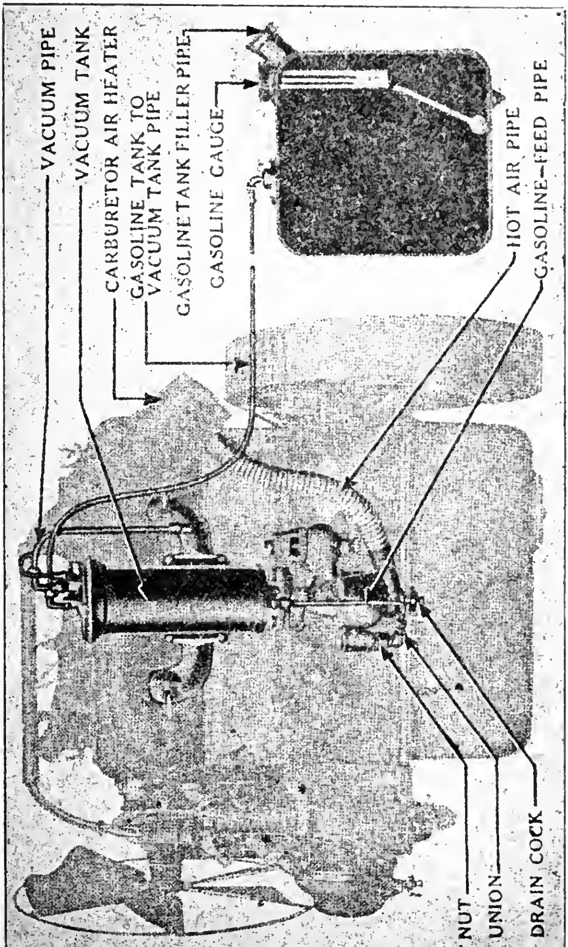


Fig. 6. Gasoline System showing Vacuum Tank on Motor and Gasoline Tank located at rear of car.

found desirable to shut off either one or both. An air adjustment is generally provided on the cowl or steering gear to control the warm air, while the hot water system is provided with a petcock so that it can be shut off.

There are also a few mechanical difficulties which may prevent the motor from starting, and which can be traced to the carburetor. These may be due to some disarrangement of the control rods from the steering gear and the accelerator pedal. This can be determined by opening and closing the throttle from the steering wheel, if small lever on the carburetor moves with the control rod, the control is correct. There is a small butterfly valve near the point where the carburetor is bolted to the intake manifold, which is attached to the same shaft that carries the control lever connected to the steering wheel. In some carburetors this butterfly valve is attached to the shaft by means of a small screw, and if the screw becomes loose it will be impossible to operate the valve, that is, the valve cannot open. If there is any trouble discovered with it, it will be necessary to remove the carburetor to tighten the screw.

7. Carburetor adjustment. Carburetor adjustments are necessary for atmospheric conditions, and certain conditions of operation. The carburetor adjustment should never be tampered with unless you are absolutely certain it needs attention. However, before making any carburetor adjustments, be sure that the ignition system is in perfect order, as in most cases this adjustment is changed before the real source of trouble is discovered. Once adjusted, there is very little danger of it getting out of adjustment. Under ordinary circumstances only an extreme change in weather conditions will make adjustments necessary.

Faulty operation of the motor will show the following general characteristics:

If the engine runs spasmodically and stops, the mixture is too lean, that is, it does not contain enough gasoline vapor in proportion to the quantity of air passing throug the carburetor. This is also the case if the engine runs with the spark retarded and a quick opening of the throttle, causing popping in the carburetor. This can be remedied by increasing the tension on the auxiliary air valve spring slowly so that a greater suction is required to open the valve.

If the mixture contains too great a proportion of gasoline, or, in other words, if it is too rich, the motor will be sluggish in its action and very black smoke will issue from the muffler, back firing through the muffler will also be noticed, due to unused gas passing through the motor and igniting there.

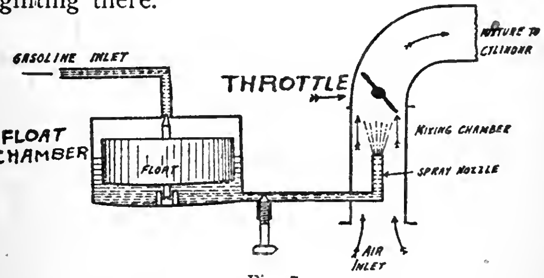


Fig. 7.

A blue smoke at the muffler indicates too much oil. It is impossible to give a detailed description of the method of adjusting the various types of carburetors. However, the above conditions apply to any carburetor, and it is necessary for the motorist to familiarize himself with the various points at which adjustments are made. It will suffice to say that a carburetor adjustment should never be attempted with motor cold and

idle. Also get the engine warmed up and make adjustments while it is running and with spark retarded for idling. When this adjustment is completed advance the spark and open throttle gradually and set for high speed.

CHAPTER V.

Removing the Query From Carburetor Adjustment.

An Illuminating Article Based on Actual Experience and Experimentation, Which Points the Way to Certain Means of Telling When the Mixture is Adjusted for Best Possible Results.

IT is one thing to tell the average car owner or operator that to obtain the best results as to power and economy from his motor, his carburetor adjustments must be just right, and quite another to explain on paper in a way that is readily understandable even to the veriest novice the ways and means of ascertaining with sufficient accuracy just when the proper carburetor adjustment for ideal operation has been reached.

The writer has had much to do with many carburetors—and the matter of obtaining the proper ,adjustment, up until a few weeks ago, has always been more or less of a compromise—bluntly a case of guesswork, pure and simple. "This" was adjusted and "that" turned slightly, the motor being put through its paces in the intervals until a point was reached where the vaporizing device seemingly gave the best results. If science entered into the process of adjustment at all, surely it must have been by "absent treatment."

The feeling of uncertainty growing out of this haphazard method of adjusting the carburetor, however, kind of upsets a fellow who wants to be sure that everything is quite correct. And so about a month ago, when I had another car-

buretor to adjust, I decided that I would attack the problem in a most scientific manner, and the results of my experience, no doubt, will prove helpful to others who now regard the matter of carburetor adjustment more as a matter of luck than anything else.

The fact that a motor will run with the mixture either far too rich or far too lean is the chief difficulty in the way of effecting a perfect carburetor adjustment. If, for instance, the mixture had to be exactly right at all times for the motor to operate at all, the matter of determining the point of proper adjustment would lose all of its uncertainty, although the task might not be facilitated. And incidentally, carburetor design would be far advanced over its present state.

Just how far wide of the mark the mixture strength can be and still permit of the motor running is shown by the fact that whereas experimentation and chemical figuring have shown that the proper proportions for ideal working conditions are 15 parts of air to one of gasoline, the motor will operate on a mixture so strong as 8 air to 1 gasoline and so weak as 22 parts of air to 1 gasoline. And, of course, it will work on any gasoline and air proportion in between these two extremes. The difficulty of attaining the exact adjustment to produce the 15 to 1 ideal mixture by the rule of thumb method will at once be apparent.

Before proceeding to the question of suitable methods of observation of mixture strength, etc., it might be of interest to state the most suitable mixtures for different purposes. Thus, for complete combustion, which gives the greatest speed of flame travel and very nearly maximum power, the mixture as above stated should be about 15 to 1. But owing to dilution of the charge by ex-

haust gases due to incomplete scavenging, and one or two other causes of theoretical interest only, it has been found that a somewhat richer mixture strength of about 12 to 1 is desirable for maximum power and acceleration, such as for speed bursts, hill climbs, etc.

On the other hand, if fuel economy is the chief end sought, a mixture of about 19 or 18 to 1 will give the best results; but this maximum fuel economy, while it will be obtained with all around good running conditions aside from easy starting in cold weather, will be gained at the expense of a slight falling off in power amounting to from 10 to 15 per cent—not a very serious factor where surplus power is provided and speed not the ultimate end in view.

Mixtures weaker or richer than those mentioned, while they will permit of the motor operating, will give bad results in the way of carbon deposit, tendency to overheat, flare backs in the carburetor, muffler explosions, etc.

There are several ways of procedure to determine the accuracy or inaccuracy of the mixture proportions. The usual method is to make certain changes in the carburetor adjustments and note the results; in laboratories, brake and acceleration tests are indulged in, the color of the explosion flame is noted or the exhaust gases are analyzed. They are all, except the gas analysis, open to the average motorist.

Take the carburetor method, for instance. Assuming that the motor is running and we desire to know whether the mixture is too weak. It is quite evident that depressing the priming pin on the float chamber will raise the level of the fuel slightly, producing a richer mixture. If under these conditions the motor picks up speed and shows an increase in power without a tendency to overheat, then it can safely be concluded that

the ordinary mixture is too weak and adjustments made accordingly.

If, on the other hand, the flooding gives rise to no speed and power increase, but causes overheating, irregular running or tendency to choke, the mixture is, or course, normally on the rich side, and this can be verified by closing off the gasoline feed for a few moments and noting whether the engine picks up speed as the level of fuel in the float chamber falls off. Another simple test for too lean a mixture is to partially close off the air supply of the carburetor. If the speed picks up, the mixture normally is too weak and should be corrected.

Power and acceleration tests for determining the condition of the mixture are not beyond the possibility of application by the motorist by any means, nor is a laboratory necessary. In the laboratory with a brake test, the procedure is usually to note the power output of the engine from the brake readings and to adjust the carburetor until this, at any working speed, is a maximum. The mixture will then be somewhat richer than is necessary for complete combustion, but will be suitable for best power results.

The same method can be applied to the case of an automobile on the road, either by adjusting the carburetor for a given throttle position and spark advance, so that the greatest speed is attained without ill effects or irregular running, or for the greatest power at a set speedometer reading such as when hill climbing.

Acceleration tests are interesting and helpful in indicating the mixture setting. If the engine accelerates much better when the gasoline supply is increased relatively to the air, it is proof that the mixture is normally too weak for the best power results. If, on the other hand, no difference in the acceleration of the car is noticed upon

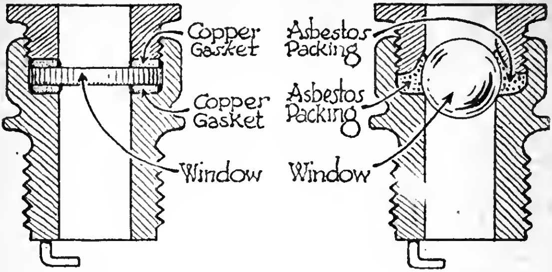
flooding the jet, or restricting the air supply, the mixture may be normally correct for best power purposes.

Another practical method is to note the gasoline consumption with different carburetor alterations and to adjust the latter until the best economy in gasoline is shown without being accompanied with a falling off in power of the motor for the same conditions as to throttle opening and spark advance. These tests can easily be made in the course of an ordinary run over a familiar stretch of road.

But to proceed to more accurate and definite ways of noting the carburetor conditions, we come to the method of observing the color of the explosion flame—a method which gives absolutely accurate results and which can readily be employed by anyone. While a measure of success is met with by the simple expedient of removing the exhaust manifold and noting the color of the flame issuing from the exhaust passages, the best plan is to make use of a quartz window so that the gases can be observed directly in the combustion chamber of the motor.

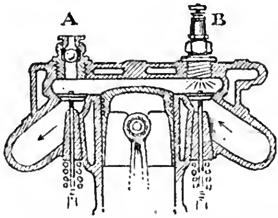
The window was made from the shell and compression nut of a discarded spark plug, a bit of asbestos packing and a clear glass marble such as the boys use to play with. The marble is of such diameter that it fits within the shell of the plug, but is sufficiently large to get a firm bearing on the shoulder within the shell which normally serves for the retention of the core. A sufficient amount of the packing is placed around the marble and tightly compressed by the nut hold the window firmly in place and still prevent leakage and breakage of the glass due to expansion and contraction.

An alternative design is shown in another sketch. In place of the marble, a small disc of



Alternative methods of making an observation window.

quartz glass is used, measuring, roughly, three-fourths of an inch in diameter and three-eighths of an inch in thickness. It is held firmly in place between two copper asbestos washers by the compression screw. The quartz can be obtained from any optician.



Where window is mounted.

The observation plug, as we will term it, is screwed home in a valve cap—an extra inlet valve cap being obtained for the purpose—which is substituted for the solid cap used over the exhaust valve. This position, directly over the exhaust valve, is the best place for the window.

As to its utility make some mixture strength measurements corresponding to different flame colors, and from these it will be shown that mixtures weaker than are required for complete combustion, such as the more economical mix-

tures mentioned earlier, give a very definite whitish blue flame during explosion, whereas the perfect combustion flame is a dazzling light-blue color.

The mixtures giving the maximum power results—but not so great fuel economy—are characterized by a slight yellowish tinge, while over-rich mixtures are indicated by a dazzling yellow flash which verges on the orange red as the proportion of gasoline to air is increased. As a means of giving positive indication as to correct adjustment of the carburetor the window cannot be beat.

It is a fairly easy matter to fit such an observation window to each cylinder of the motor and to observe the color of the flame while running. It is even feasible to observe, by means of reflectors the flame color while running on the road and to adjust the carburetor accordingly to give the best possible results throughout the entire speed scale.

Turning finally to the exhaust as an indicator of the carburetor conditions, some observations of its color, smell and sound can be taken as rough indications of the mixture strength. Thus, placing a white background at the muffler orifice, the color of the exhaust gases should show a faint brown tinge when the mixture is about correct, whereas richer mixtures show a distinctly darker color, due to finely graded carbon particles. Again, the pungent odor of the ultra rich mixture exhaust is quite characteristic and distinct from less rich mixtures.

The actual sound of the exhaust, with a little practice, can be taken as a sure guide to the carburetor's action, for there is no mistaking the healthy note of the proper mixture, compared with the partially muffled and prolonged exhaust beats in the case of over-rich and lean mixtures

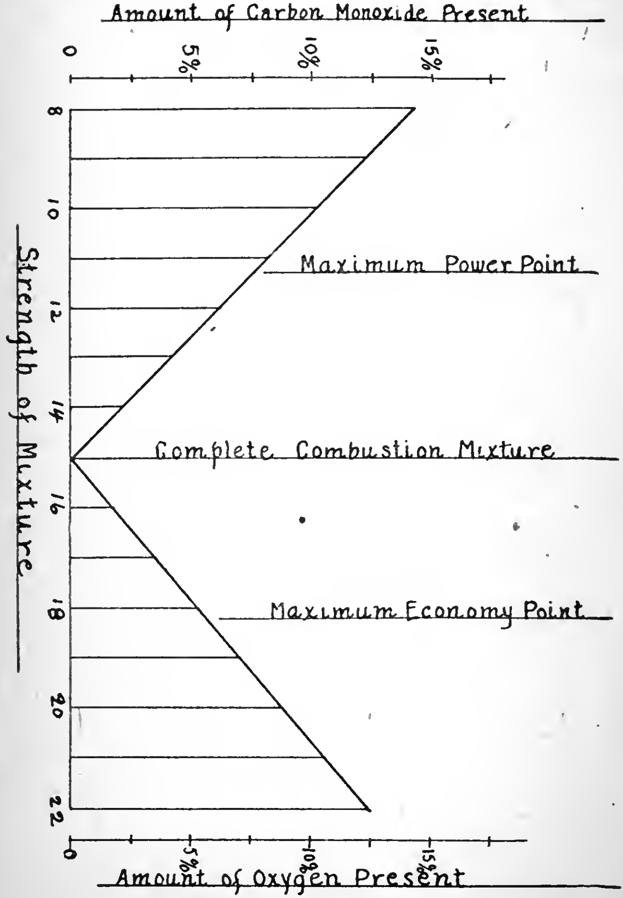


Chart for determining proper carburetor setting from exhaust gas analysis.

in any given engine, other conditions remaining the same.

There remains the method of exhaust gas analysis, which, of course, is beyond the scope of the average motorist. The accompanying chart, which approximates the conditions obtaining where the exhaust gases are analyzed under all conditions as to mixture strength, from the very weakest on which the motor will operate to the very richest.

It will be seen that on the rich mixture side of the scale there is a constantly increasing proportion of the gas "carbon monoxide" present in the exhaust gases, while on the weak mixture side of the scale the same is true of the gas "oxygen." Neither of the gases is present in appreciable quantities at the 15 to 1 point, the condition for complete combustion of the fuel.

CHAPTER VI.

Operation and Care of Vacuum Tank.

How the Stewart Fuel Feed System Works Described in Detail—Some Suggestions for Dodging Trouble and Correcting Faults.

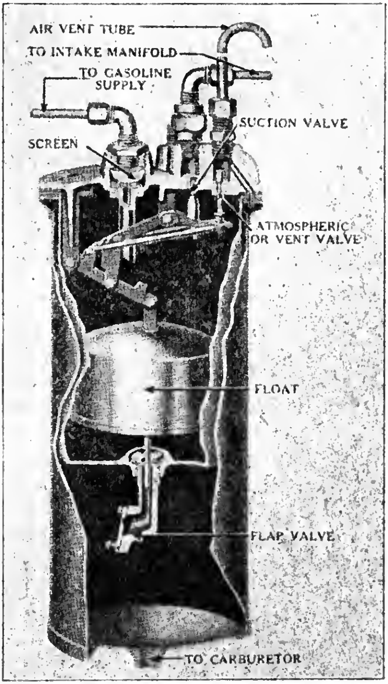
INDICATIVE of the readiness with which the motor car designer takes up a "good thing" is the case of the vacuum feed system for insuring a plentiful supply of gasoline to the carburetor at all times, regardless of the position of the tank, the inclination of the car or the several other drawbacks that sometimes lead to failure in the case of the gravity and pressure feed systems and modifications or combinations of the two.

It was only a few years ago—in 1913, to be exact—that the first vacuum tank made its appearance. Yet a recent canvas of the present automobile offerings reveals the fact that practically all of the cars have adopted the system as standard equipment.

The Stewart vacuum gasoline feed system, which is the pioneer in the field, smploys a small supplementary gasoline tank under the hood of the car. This tank is connected by copper tubing to the intake manifold of the motor, to the inlet into the carburetor float chamber and also to the gasoline supply tank, whether that is located under the seat or at the rear of the car. Simply explained, its action is as follows: When the motor is turned over, the pumping action of the pistons creates a partial vacuufm in the inlet manifold and this vacuum is utilized to draw the gasoline from the supply tank into the smaller supplementary tank under the dash. The feed

from the small tank to the carburetor is by gravity.

The vacuum tank comprises two chambers. The upper one is the filling chamber and the lower one is the emptying chamber of the



Sectional View Vacuum Tank.

vacuum tank. Between these two chambers is a partition in which is placed a valve. The suction of the pistons on the intake creates a vacuum in the upper chamber and this suction is sufficient to close the valve between the two chambers and also suck the gasoline from the

main supply tank into this upper chamber. As the gasoline flows into this upper chamber it raises a float valve.

When the level of the gasoline has risen to a predetermined point, the float valve comes into play and it shuts off the suction and at the same time opens a vent admitting air through the vent tube. The admission of the outside air soon destroys the vacuum within the inner chamber, so that the valve between the two chambers is opened by the pressure of the gasoline, permitting the fuel to pass down into the lower chamber. This chamber is always open to the outside air, so that there never is anything to prevent the flow of the gasoline from this point to the carburetor.

When enough of the gasoline has passed to the lower chamber the falling float again opens the suction valve and closes the vent valve so that more gasoline is drawn from the tank. The action is continuous and absolutely automatic, so that there is always a free flow of gasoline to the carburetor, and the fact that there is always enough gasoline held in reserve in the supplementary tank insures plenty of gas for starting without the necessity of turning over the motor to draw it from the main tank, or operating any pumps, as was the case with the old pressure feed system. Neither will the flow stop because of the inclination of the car on a hill or for any similar cause.

It is best to leave the vacuum feed tank alone; don't tamper with it. It is not very likely that it will ever be necessary to open the tank, but if it is opened, follow these instructions carefully: Before proceeding to repair the vacuum feed tank, make absolutely sure that the trouble is not due to some other cause. Remember that failure to feed gasoline to the carburetor may

be due to causes other than the vacuum system. Therefore, do not blame the vacuum system until you have made certain that the fault does not lie elsewhere.

After lifting the cover from the float of the carburetor and finding no gasoline in the float chamber, you can be certain that the upper chamber in the vacuum tank is not delivering gasoline to the lower chamber. This may be caused by lack of fuel in the main supply tank or the filler cap of the main tank may have the vent hole stopped up. It may also be due to a leak in gasoline line or its connections, the lead to the manifold, or the manifold itself. Or again it may be caused by the fact that the float, which should be air tight, has developed a leak, permitting the entry of gasoline, which prevents it rising sufficiently to close the vacuum valve. In this case, the pure gasoline will be drawn into the manifold, choking up the motor. Proper operation depends upon the float being air tight.

If a leaky float is discovered or suspected, remove the top of the tank to which the float is attached, by taking out the screws around the upper rim and running a dull knife blade around the top between the cover and the body of the tank, so as to separate the gasket without damaging it. The gasket is shellaced in order to make an air tight joint. Dip the float into a pan of hot water in order to determine definitely where the leak is. Bubbles will be seen at the point where the leak occurs; mark this spot.

Next punch two small holes, one in the top and the other in the bottom of the float, to permit the gasoline to run out; drain the float thoroughly and then solder up these holes and the leak. Test the float in hot water again. In soldering the float be careful not to use more solder than is

absolutely necessary, for an excess of solder may make the float too heavy for perfect operation. Be careful, also, not to bend the float guide rod when you are taking out or replacing the float. If it should be bent, it will strike against the guide and retard the float, producing the same effect as a leaky float and allowing gasoline to enter the inlet manifold. Make certain, also, that the surface of the guide rod is perfectly smooth, so that it cannot stick in and be retarded by the guide.

To overcome the condition of a leaky float when you are on the road, and not handy to a garage or repair shop, remove the plug on top of the tank. Sometimes the suction of the motor will be sufficient to draw up the gasoline from the main tank despite the fact that the plug is removed, and in this case you can proceed without difficulty to your destination. This is not always the case, however, so that it will sometimes be necessary to close up the plug with the motor running, thus allowing the motor to draw up a tank full of gas. Then open the plug to prevent further action and proceed until the vacuum tank is empty again. There is enough gas in the tank, when full, to carry you for two or three miles, when the process will have to be repeated until a shop is reached where the leaky float can be repaired.

Another possible source of trouble is the "flapper valve," which controls the flow of gasoline between the two chambers within the tank. A small particle of dirt under the valve will prevent perfect seating and render the tank inoperative. In order to recognize this condition, first plug up the air vent; then detach the tubing leading from the tank to the carburetor from the bottom of the tank. Start the motor—the carburetor bowl being filled with gasoline for

the purpose—and apply the finger to this opening. If suction is felt continuously, then it is evident that there is a leak in the connection between the tank and the main gasoline supply, or else the flapper valve is being held off its seat and is letting air into the tank instead of drawing in gasoline.

In many cases, this trouble of a sticking valve can be stopped by tapping the outside of the tank, thus dislodging the particle of dirt or lint that is clogging the valve. If this does not prove effective, remove the tank cover, as described above, and lift out the inner tank. The flapper valve will be found screwed into the bottom of the inner tank.

Other causes of a dry carburetor are a loose manifold connection permitting the entry of air into the manifold and destroying the vacuum or clogging up the one or other of the tubes connecting the vacuum tank to the motor and its appendages. All these things should be looked for in turn. But, once again, before taking the tank apart make sure that the main tank is filled, that the vent in the filler cap not clogged up and that the sediment trap in the main fuel supply line leading into the vacuum tank is not clogged up.

CHAPTER VII.

How Wear Affects Valve Timing.

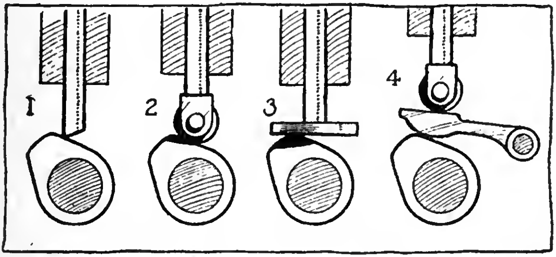
Constant Movement of Valve Mechanism Results in "Play" in Parts Which Seriously Affect Power—How Faults Can be Corrected and Timing Verified.

THE opening and closing points of the valves are important factors in the efficient operation of the internal combustion engine. Variation is caused by wear at a number of points such as cams, rollers, tappets, pushrods, etc., as these components are subjected to considerable service. Generally the greatest wear occurs in the tappet and on the end of the valve stem, causing the valve to open late and not lift high enough, thus retarding the flow of the mixture to the cylinder.

Generally the opening and closing points of a motor are marked on the periphery of its flywheel by the manufacturer. The figures and letters and their application are understood easily if the motor's cycle of operation be taken into consideration.

The figures 1, 2, 3, 4, represent the cylinder, while the letter I indicates the intake valve and the letter E the exhaust valve. Thus the combination I, O, 1, 3, signifies the opening point of the intake valves of the first and third cylinders. Another set is I, C, 2, 4, which indicates the time the intake closes. Similarly, E. O, 1, 3, means the opening point of the exhaust valves of the first and third cylinders. E, C, 1, 3, is the closing point. The letter C is generally employed for denoting the top and bottom centres.

If it be remembered that the explosions of a four-cylinder, four-cycle motor do not occur in consecutive order, that is, the arrangement of the crankshaft is such that two pistons are up and two down at the same time, as indicated in an accompanying illustration, the timing will be simplified. Referring to the sectional view of a motor, it will be seen that the piston of the first cylinder (that nearest the radiator) has completed the compression stroke, that both valves are closed, and that the mixture is ready to be

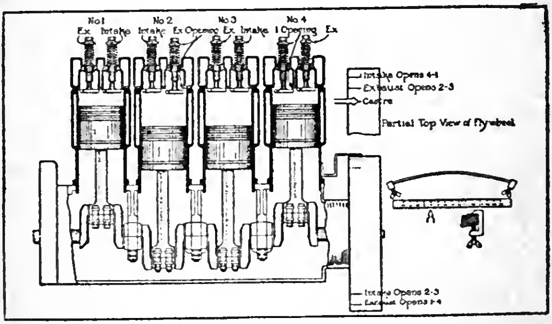


Four types of Tappets illustrating where wear occurs.

ignited by the spark. The pistons of the second and third cylinders are practically at the bottom, these being ready to begin the exhaust and compression stroke respectively, as may be noted in the drawing.

The firing order of the motor is 1, 3, 4, 2, which means that the charge is ignited in this order. Another firing order is 1, 2, 4, 3. In either case, however, there are four strokes of the piston and two revolutions of the crankshaft to obtain one impulse or firing stroke. By referring to the firing order below the illustration it will be seen that the sequence of the strokes is: Firing, exhaust, compression and suction or intake. By utilizing these tables one may become familiar with the

order of explosions, and these figures may be utilized in timing where the flywheel is not marked. Where wear has taken place at the tappet or valve stem, and these members are adjustable, the efficiency of the motor can be improved greatly by resetting to conform with the figures on the flywheel, previously mentioned. While some makers advise the use of a business card, inserting it between the valve stem and tappet, the better method is to utilize the flywheel marks.



Illustrating How Valves Are Timed and Tappets Adjusted by Utilizing Markings on the Flywheel.

FIRING ORDER, 1-2-4-3.

Cylinder 1	Cylinder 2	Cylinder 3	Cylinder 4
1—Firing	Compression	Exhaust	Suction
2—Exhaust	Firing	Suction	Compression
3—Suction	Exhaust	Compression	Firing
4—Compression	Suction	Firing	Exhaust

FIRING ORDER, 1-3-4-2.

Cylinder 1	Cylinder 2	Cylinder 3	Cylinder 4
1—Firing	Exhaust	Compression	Suction
2—Exhaust	Suction	Firing	Compression
3—Suction	Compression	Exhaust	Firing
4—Compression	Firing	Suction	Exhaust

Generally an indicator in the form of an arrow is fitted to the motor and its parts to facilitate the work of the timing, but if the engine be not thus equipped, it will be necessary to make a mark on the cylinder to indicate the centres.

The mark may be checked by placing the piston of the first cylinder at the top of its stroke, or by having the crank throws vertical.

As has been previously explained, the crankshaft makes half a revolution to each stroke. Referring again to the drawing, it will be seen that the first cylinder is about to fire and that both valves are closed. The exhaust of the second is about to open. If the timing be correct the indicating arrow will register with the line on the flywheel marked E, O, 2, 3. If late these figures will pass by the indicator and the tappet of the exhaust valve of the second cylinder should be lengthened until the valve starts to lift with the arrow and line coinciding.

By moving the flywheel slightly the marks I, O, 4, 1, should appear as the intake valve of the fourth cylinder starts to lift, and if it does not the adjustment of the tappet should be altered. If the flywheel is now given approximately half a turn the markings for the exhaust valves, 1 and 4, and intake, 2 and 3, will appear and can be checked. If the closing points are included in the markings on the flywheel, it is advisable to utilize them.

When the flywheel is not marked the timing will have to be secured from the factory. A gauge will be useful in the work and one can be made from a strip of brass about 1/16 inch thick and about one-inch wide. The length of the material will depend upon the diameter of the flywheel, and as the general average is about 15 inches, a foot and a half of metal will be sufficient. The fraction of an inch that equals a degree is figured out and marked on the brass as indicated in the drawing. This is essential, as generally degrees are utilized. The degree can be calculated esaliy as 360 degrees equal a circle.

In employing the gauge the top and bottom

centres of the flywheel are located, and while these may be obtained by inserting a rod through the opening of the compression cock, the better method is to remove the crank case or a baffle plate and make sure that the crank throws are exactly vertical and the piston is at the top of its stroke. In fine timing some allowance should be made for wear of the timing gears, play in the bearings, etc.

After locating and marking off the centres on the flywheel, and providing an arrow or other indicating mark, the gauge is clamped or secured to the flywheel as shown in the illustration. The degrees in inches are then laid off and the timing may be checked.

All corrections should be made with the motor warm in order to obtain the best results. The relief cocks should be opened, or better still, the plugs taken out of the cylinders, so that the flywheel may be rotated easily. If the compression is not relieved it will be difficult to turn the wheel by hand, as well as maintain it in the position desired. The adjustment of the valve openings is a simple matter and the operation will be facilitated by studying the accompanying illustration, which was drawn to make clear the valve openings and the markings on the flywheel.

CHAPTER VIII.

Giving the "Third Degree" to a Balky Motor.

Just What to Do and How to Go About It When the Engine Refuses to Behave.

FINDING out the trouble with an automobile when it won't run is, according to experts, like running down a crime. It is a process of cool and logical elimination. The motorist, unless he be an expert himself, reading sounds and signs with swift and unfailing accuracy as to their cause, should first clear his mind of all prejudices and passion. Every preconception should be magnanimously dismissed from his thoughts, no matter how great his haste, how inclement the weather, before, seeking the truth and nothing but the truth, he begins to cross-question the auto by trying one part after the other.

If the engine stops on the road and pressing the starter pedal refuses to start it, the first thing to do is to get the crank out of the tool kit and crank over the engine. If, with the gears in neutral, the engine cranks over hard, it indicates a lack of lubricating oil or a lack of water, which has allowed the engine to reach a temperature where the lubricant fails to perform its work. If the engine turns over fairly easy it is not necessary to look for oil or water trouble.

The next test is for compression. If the driver is not experienced and is unable to tell simply by the resistance to the starting crank if each cylinder has compression, he should open all petcocks except on one cylinder and turn the crank over two revolutions, noting if there is

a resistance for one-half of a revolution in the two revolutions. Compression occurs only on one stroke of the piston in the four-stroke cycle. Each cylinder should be tested in a similar manner, opening all petcocks except on the cylinder being tested; see if the compression is practically equal in all cylinders. If one cylinder has very weak or no compression, the trouble will be found usually in the exhaust valve. First examine the push rod to see if there is clearance between it and the valve when the valve is supposed to be closed; if there is, the valve must be lifted out and seat inspected for carbon. Sometimes a piece of carbon will lodge on the valve seat and due to the hammering of the valve, will become fastened to valve or seat. For temporary repair generally it can be scraped off with a knife and the valve be ground in upon reaching the garage.

If the trouble is not in the exhaust valve, it might be in the inlet valve. In some types of engines the valve head may break off and get into the cylinder and when the piston comes up punch a hole in the piston head. A petcock may be loose so that it will jar open sufficiently to affect the compression and so cause the cylinder to miss fire. These troubles usually are confined to one cylinder and not to the whole engine.

The gasoline is the next to be inspected. Is there any gasoline in the bowl of the carburetor? This may be determined by inspection, opening draincock, or "ticking"—flooding. If not, examine gasoline tank and see if there is a supply; then see if the shutoff valve in the line leading to the carburetor is open; if so, drain the bowl of the carburetor to get rid of possible water and dirt. To check the possible clogging of gasoline pipe or carburetor screen, notice if the bowl fills up again in a reasonable time.

Do not adjust the carburetor. If the engine has been running it is practically certain that the carburetor has not become out of adjustment. Inspect the intake pipe, or manifold, to see if it has been loosened by vibration. If the engine still refuses to run, put about a tablespoonful of gasoline in each cylinder and crank over the engine. If this runs the engine for a few revolutions it indicates that the trouble is in the gasoline system and leaves but the spray nozzle, which may be stuck, as remaining causes.

Next inspect the ignition system. The first thing to do is to loosen one of the wires from a spark plug and lay or hold it so the bare end will be one-eighth of an inch from the base of the plug and have some one crank the engine by hand or with the starter. If a spark does not occur, go first to the interrupter points and short circuit the fixed point with a screwdriver or other metal tool and see if there is a spark. Examine the points for dirt and see if they come together and open properly. Then examine the condition of the battery, testing it. Examine the connectors on the battery, which sometimes jar loose; examine the wires leading to the interrupter switch; see if they are loose, or broken, or short circuited. This need not be done if the spark shows at the interrupter.

Examine the distributor for moisture or dirt and see if the wires have become loose. If a magneto only is used, it is a simple matter to see if the interrupter points are making and breaking properly, and if the distributor is clean and dry. If these appear to be all right the trouble is doubtless in the armature winding or the condenser and cannot be repaired upon the road.

The wires to the plugs may be burned or short circuited. If, with an apparently good spark, we have compression and there is a mix-

ture passing into the cylinders, the trouble may be in the spark plug. To test a spark plug it is necessary to remove it. Widen the gap to one-eighth of an inch and lay the plug with wire attached upon the cylinder; crank the engine and see if the spark jumps the gap. Widening the gap is necessary, because the spark will not jump so far under pressure as in the open air. If it does not jump, the plug may have a broken insulator or need cleaning. An extra set of plugs should be carried to replace those which become dirty; cleaning should be done in the garage. If uncertain about condition of plug, exchange it with one in another cylinder that is working properly.

This covers most of the usual troubles experienced on the road. There are, of course, a great many other possibilities, but if these tests, carefully made, do not disclose the cause of the trouble, it is advisable that the novice send for a garage man. If one or two cylinders miss fire, the trouble is most likely to be caused through lack of compression or short-circuited spark plug. If the engine refuses to run, the trouble is most likely to be due to lack of gasoline or failure of battery or magneto.

CHAPTER IX.

Applying Logic to Difficult Starting.

Tracing Starting Troubles to Their Source by the Process of Elimination and Effecting Cures.

WE should think logically. That is, after all, the best advice for those who experience difficulty in starting, and are unable to assign a cause. It can be applied to every trouble experienced with a car. There must be a reason. Find that reason and the cause is soon curable.

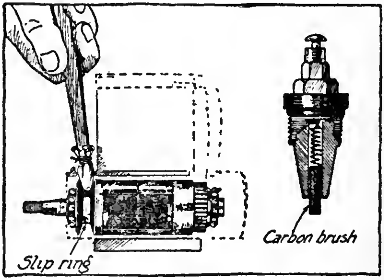
Now, when it comes to assigning a cause for an engine that regularly requires a considerable amount of "cranking" before we are rewarded with the syncopated music of its four cylinders, we have, after all, very few factors to consider. We are assuming that in the ordinary way the engine runs evenly and pulls well, as in the majority of cases where the only difficulty is in starting up from cold, and therefore many factors can be left out of consideration. The process of reasoning, therefore, is this:

Provided we introduce a volatile inflammable mixture into the combustion chamber and a spark of sufficient intensity to fire the charge, the engine must start. We will, therefore, begin to examine either one or the other of the two conditions to see if they are produced, which is far better than violently flooding the carburetor, opening the throttle lever and furiously "spinning" the motor in heroic but purposeless efforts to induce the motor to start.

Let us consider the question of the spark first, because it is usually the prime cause of difficulty

in an engine which otherwise behaves as it should, and is invariably given the least consideration. As the quickest means of determining whether the cause of the trouble is to be looked for in this direction, take out one of the spark plugs, with the high tension lead firmly attached, and lay it on top of its cylinder in a position where the points can be seen.

Moisture condensing on the electrodes is a frequent cause of failure to start and the plug should be examined for the presence of water immediately on removal from the cylinder. With



the plug in position on the cylinder, turn the motor over. If the good fat speark jumps across the points, we can perceive at once that the plug or the spark is not a likely cause of the hard starting, and go on to investigate the carburetor. If, however, there is no spark at all, or one which is a mere pin point of blue flame, we have by far the likeliest cause of difficult starting. The very best mixture will not ignite under these circumstances.

It is as well to turn the motor over twice or three times to make sure that the firing point is reached with the plug under test and to ascertain also that the magneto is not cut out at the switch. We will presume that there is no spark

at all. The cause must be considered. Either the magneto is not producing the spark or we are disseminating the current generated in other useless ways. Let us adopt the latter assumption.

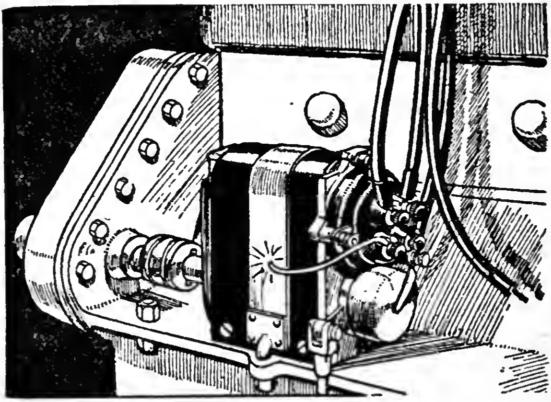
First, examine the plug. It may be sooted up internally, which is not hard to discern. We can either disconnect the high tension lead and see if a spark can be produced from the terminal at the plug end almost in contact with the cylinder, or we can connect up the new plug and test it out in this manner. If a satisfactory spark is now produced, we have located the trouble, which can be cured by changing the plugs, or by cleaning the old ones and resetting the spark gaps to the proper opening, about the thickness of a visiting card.

Perhaps the test reveals that there still is no spark or a very feeble one. We are presuming that the starting crank is given a fairly rapid turn for each test, although it is surprising what an excellent spark can be produced from a magneto by merely turning the armature shaft over comparatively slowly, as we can test for ourselves any time the magneto is removed from the power plant. If the motor is very stiff when cold, the thickening of the lubricating oil and the gummy condition of the cylinders and bearings are prime causes of hard starting. The remedy is the use of a thinner oil and a more frequent emptying of the oil sump in cold weather. These possibilities being eliminated one by one, let us proceed to the magneto.

A frequent cause of a weak spark is the dirty condition of the cutout or grounding terminal on the magneto. The current will leak rapidly through oil and grease at this point, although moisture, which will sometimes collect here, is a better conductor and more likely to be the seat

of the trouble. We should disconnect the wire, clean the terminal thoroughly and try again. Still no success? Well, the magneto itself then is the probable cause.

First of all, however, disconnect the high tension lead on the test plug, clean the magneto terminal, and attach instead a piece of stiff copper wire with which we can short circuit the spark back on to some part of the magneto itself or to some part of the chassis. If we now get a



Eliminate leakage of the high tension lead.

spark, we establish the fact that the current is leaking through the leads and can cure it by installing new high tension cables and making sure that the terminals are in proper shape. After a car has been in service for a few years the cables are quite likely to be found with cracked insulation, which collects moisture and permits the escape of the high tension current from the magneto.

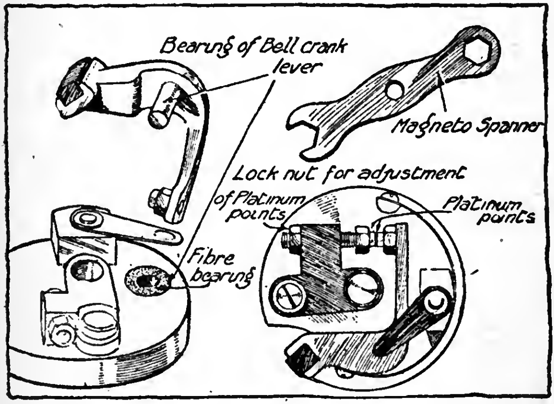
There still being no result, the trouble must lie in the magneto, and as once the engine starts there is no particular cause for complaint, we

must look for some likely reason which would manifest itself at low speeds, viz., a sticking contact breaker, imperfect carbon brush and slip ring, dirty distributor, or demagnetized magnets. Examine the contact breaker, and as the engine is turned over, see that the points open and close.

Quite often, especially when the motor is cold, the bell crank lever in the circuit breaker sticks on its fibre bearing. It must be taken out, and very lightly trimmed with a rat tail file, smearing a little vaseline on the bearing before replacing, when this trouble will be cured. The platinum points may be worn or set too wide. Their adjustment is a simple matter, and they can be filed dead flat with a special magneto file. They should open not more than the thickness of a visiting card. Taking out the carbon brush, it may be found broken, in which case it must be replaced with a new one. The end, provided the brush is found not broken, should be rubbed on a piece of fine sand or emery paper to roughen up and clean the surface. The brass segment of the slip ring may be blackened or streaked with oil, the result of too frequent oiling of the magneto bearings. It must be cleaned with a piece of rag dipped in gasoline while the armature shaft is rotated. The distributor brush and segments, similarly, must be cleaned.

If, after attention to these details, we still fail to produce a spark worthy of the name, it is fairly apparent that the magnets require remagnetizing, which is a job beyond the capactiy of the ordinary amateur, and the whole magneto should be sent to a concern specializing in magneto repairs or to the nearest service station. The magnets on a first-class magneto should last fully four years without attention. If we were troubled with irregular firing through the entire

range of motor speeds, and inexplicable engine stops, or the engine had given out altogether, we could look for much more serious trouble with the ignition, but we are assuming that the only trouble is difficult starting, and we are working for a cure on that premise. It is highly probable that long before the test has gone this far the cause or causes of the trouble will have been located.



Examine the contact breaker and platinum points.

Now we will consider the other prime cause of difficult starting. The mixture is not one that is readily ignited even by a good spark.

If the application of heat to the carburetor and inlet manifold provides a cure, the trouble is caused by condensation of the mixture, caused by too long an inlet pipe. It can be covered with flannel or some other heat retainer with advantage, but defective motor design is difficult to cure. Here is a tip, however, that has been found to work wonders. Soak a rag in gasoline and place it over the air intake of the carburetor. A few turns of the motor will generally

suffice for starting, and once the motor starts it heats up so readily and will in a few moments be running regularly, when the rag can be removed. The rag provides a vapor instead of a liquid vapor, which must be further broken up in the manifold, the vapor being more readily ignited.

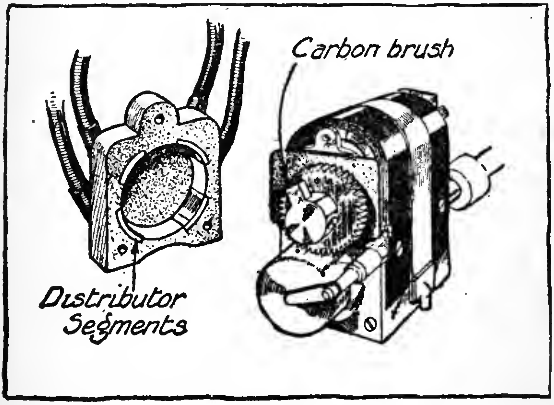
See that all the conditions for easy starting are followed before making further investigation. Advance the spark to the maximum point it will stand without the motor "kicking." See that the switch is on and the gasoline cock opened. Flooding the carburetor until the gasoline runs over freely is a frequent cause of difficult starting, because the mixture thus produced is likely to be far too rich. Try the effect when the engine is warm and note the tendency to choke and stop.

If the throttle is set rather fine for slow running when warm, open it slightly, and when the correct point is found by successful starting, note it forever more! With nearly every carburetor, it is difficult to start up on a fully opened throttle, the reason being that the fuller volume of mixture increases the compression in the cylinders and the higher the compression the weaker the spark. As a final try, turn off the switch and spin the motor over a number of times to draw into the cylinders a good fresh charge and then switch on again, giving the engine a good quick turn or "spin" it.

With every condition favorable for easy starting, and yet with no success, we must look to the carburetor, possible losses of compression and air leaks in the intake system. The last mentioned cause is the most difficult to locate, but it should be possible to counteract its defects by gradually raising the level of the gasoline in the float chamber of the carburetor, opening the

throttle, and partly, then wholly, cutting off the air supply.

A loss of compression is easy to determine, but it will almost certainly not exist in a new motor, and when present generally varies on the different cylinders. Thus, if two or three cylinders seem to have a fairly good compression, while the third and fourth have practically none, we have a good cause of difficult starting, the remedy for which is an examination of the pis-



Clean the distributor ring and carbon brush.

tons and rings, and valves. Sometimes the steps or slots of the rings are lined up, causing the leakage. A keen car will discover a loss of compression when the motor is turned over.

Look also at the spark plugs and valve caps, where a leakage will usually be determined either by a hissing sound when the motor is running or by the presence of oil.

We can now look at the carburetor, especially the slow running adjustment or pilot jet, which may be partially choked. Unfortunately, to give instructions for tuning and adjusting each make

would take up a considerable amount of space. Only by constant trial and retrial will the correct adjustment be found. Probably a different setting will be necessary for cold and warm weather running.

With regard to air leaks in the inlet system, you may discover the cause in a carburetor which while being tightly bolted to the motor, when originally installed, had gradually worked loose, giving rise to an infinitesimally small air passage way through the flange, which was sufficient to make difficult starting.

In an old motor it is best to look for a worn inlet valve guide, which will require rebushing, or a new valve may cure the trouble. If one valve guide is found to be worn, the other will probably be found in like condition. The valves and valve seats may require regrinding. Whenever there is the possibility of an air leak occuring between the carburetor and the cylinders, it must be guarded against, and in so far as external connections are concerned, there is nothing better than shellac, or tire tape covered with shellac.

CHAPTER X.

The System That Is Eliminating the Magneto.

Introduction of Dynamo On Starting and Lighting Systems Has Brought About a New Regime in Automobile Ignition—Features of Generator-Battery System.

WAY back in 1912 when electric starting and lighting systems began to make their appearance, automobile engineers with foresight predicted the abandonment of the magneto in time to come for ignition work on cars fitted with the starting and lighting systems. The prediction is coming true as a matter of course, for with simplification the keynote in modern motor car construction the retention of two devices, the magneto and the starting and lighting dynamo, both employed for the identical purpose of generating electricity, would be wholly inconsistent.

The high tension magneto, it will be understood, is being thrown into the discard, insofar as the pleasure car is concerned, not through any failure on its part to perform its allotted function in a most satisfactory manner. Indeed, the performance of the magneto has been so creditable that until the starting and lighting system came into being it was the universal means of obtaining ignition having entirely superseded the old battery and coil system and even now, in bringing to the attention the merits of the newer generator-battery ignition which is surplanting the magneto.

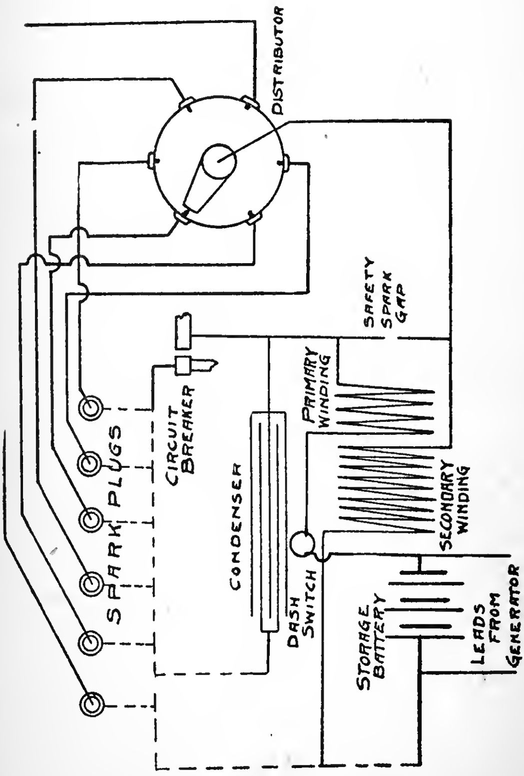
A glance at the accompanying diagram will serve to make clear to the reader the fact that

to all intents and purposes, the generator-battery system of ignition is identical, as to principles with the magneto system.

In the magneto system, current is generated at comparatively low voltage in the primary winding of the armature, and "stepped up" to sufficiently high tension to jump the spark plug gaps in the secondary coil also placed on the armature. The high tension current thus available is led to a high tension distributor where it is distributed to the various plugs at exactly the proper moment for the ignition of the gases. A cam actuated circuit breaker, providing an exceedingly rapid break is inserted in the primary circuit and serves to provide the necessary rapid drop in voltage to cause the high tension surge in the secondary winding and a condenser is connected across the points to eliminate sparking.

All this is identical with generator-battery ignition; there is the same primary winding, which with the motor running takes current at low tension from the generator; there is the finer secondary with its "business end" connected to the high tension distributor; there is the rapid circuit breaking device which breaks the circuit and produces the surge at just the proper instant for ignition in each of the cylinders; there is the spark-preventing condenser; everything identical. The only difference lies in the fact that the transformer coil in which the current is stepped up from low to high tension instead of being mounted on the armature of the magneto is contained in a neat little box which in usual practice is screwed well out of harms way to the dashboard of the car.

The current supply of the generator-battery ignition system is constant, regardless of the engine speed. The magneto is necessarily limited in its output and can not be increased beyond a



Circuit Diagram of the Generator-Battery System. The Secondary and Primary Windings with an Iron Core Constitute the Transformer Coil.

certain limit. The storage battery supply is flexible. If the resistance is high, more current can flow from the battery to break it down. If the resistance is low, the current flow is reduced correspondingly. With the source of current absolutely independent of the engine speed, the spark may be advanced or retarded without affecting the intensity of the spark. With the hot spark at low speeds, the engine throttles down perfectly under load.

In any magneto using the common shuttle armature and the fixed pole pieces there are but two positions in each revolution that give the maximum current, and the primary circuit should be broken at one of these positions to give the maximum intensity spark. Obviously, the range of speeds of the automobile must be great to overcome the road conditions encountered. A fixed spark will limit the range, and the necessity of retarding and advancing the spark arises. Since there is as much as thirty to forty-five degrees variation in the crankshaft position of the occurrence of the spark throughout the range of advance, the spark can not occur always when the magneto armature is in the position for maximum current, and the spark varies in its intensity.

The character of the spark is identical in either the magneto or the generator-battery system. There is but a single spark across the gap of the spark plug in both cases, so that there is no difference between the two systems in regard to this feature. The generator-battery system should not be confused with the vibrator coil system that has been practically abandoned. There is no vibrator in this entire system.

CHAPTER XI.

Features and Care of Ignition Systems.

Differences Between Open and Closed Circuit Quick Break Types—Operation of Atwater Kent Unisparker Made Plain.

WHILE in their basic principles all of the quick break battery ignition systems fitted to modern cars are quite similar, in their mechanical, as well as their electrical details, there are points of divergence which lend individual merit to the different makes. Broadly, the system is divided into two broad classes—the open and the closed circuit types—each of which has points of value not discernable in the other class.

The points of difference between the open and the closed circuit types are made perfectly plain by the accompanying sketches. With the closed circuit type, it will be seen that the spring tends normally to keep the circuit breaker contact points closed, until the cam revolves enough to open the contact points, thus producing the spark to fire the charge. Its big feature is its extreme simplicity and fewness of parts; it is the type found on most of the low and intermediate priced cars.

On the other hand, with the open circuit system, the spring tends normally to keep the points apart and the circuit broken; the cam is brought into play in order to bring the points together and establish the circuit. This is done through another spring or a system of levers. It is not quite so simple as the closed circuit system, but the added complication results in a construction which has material advantages over

the simpler type. With the latter, for instance, as the speed of the motor increases, the intervals when contact is made decrease in exact ratio with the revolutions of the motor. This means that at a speed of 1,000 r. p. m. there is just twice the time provided for the current flow as at a speed of 2,000 r. p. m.

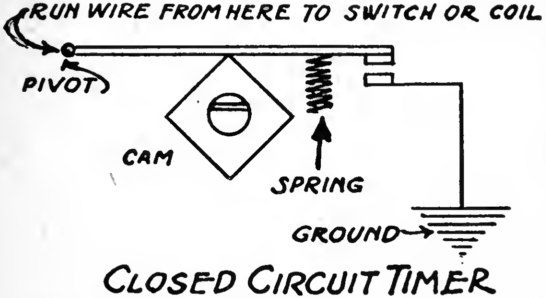


Diagram of closed-circuit system of ignition, with contacts in open position.

In other words, if the adjustment is made so that the contact interval is just proper to provide the maximum spark with minimum current consumption, at say, 2,500 r. p. m., at low

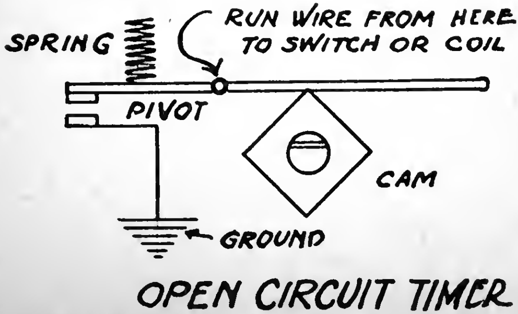


Diagram of open-circuit system of ignition, with contacts in open position.

speeds, there is a waste of battery current, while at speeds higher than this set point the full effectiveness of the spark cannot be attained. This is so because it takes some slight interval to complete the mechanical act of establishing the contact, for mechanical appliances cannot act instantaneously, while it also takes some slight interval for the voltage or surge of electric current in the primary winding of the coil to reach its maximum. In other words, there is both a mechanical and an electrical "lag" and the best

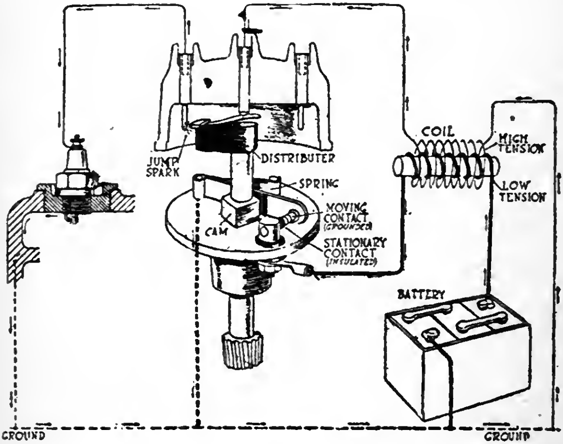


Diagram illustrating principle of all types of battery ignition system.

results are attained only when the duration of the contact is just right to compensate for both the mechanical and the electrical "lost motion."

With the open circuit system, however, the speed of the motor has no effect on the length of the interval the contacts are held together. Whether the motor is turning over at 500 r. p. m. or at 3,000 the contact interval is the same,

and having been so adjusted at the factory, is always just right to provide the maximum ignition effectiveness. Not only is this more economical of current, but it also results in a better running motor.

Aside from this slight mechanical variation, however, one quick break battery system is much like the next so that one schematic diagram will serve to make known the basic principles on which all systems of this character operate. By reference to the next figure, we find, for instance, that with the exception of the coil, the entire mechanism is built around a single vertical shaft which is sometimes built in a unit with the battery charging generator, but which always is rotated from the timing gear train at one half crankshaft speed. Mounted directly on this shaft is the cam, while the breaker contacts and the springs and other mechanism which enter into the circuit breaking mechanism assembly are carried on a plate enclosed with a Bakelite cover, the plate being held normally stationary, but arranged so that it can be rotated through a slight angle in order to provide for advance and retard of the spark.

The movable member of the contact breaker is usually grounded directly to this plate, while the stationary member, which is adjustable to compensate for wear and burning of the points, is insulated from the plate by means of suitable bushings. To the terminal on the insulated contact is connected one of the primary leads from the non-vibrating type of coil which usually is mounted behind the dash of the car, the other primary lead being connected to the battery; the ignition switch is interposed to control the current as a matter of course. The other or negative terminal of the battery is grounded. It will be seen, now, that when the contact is estab-

lished, the current flows from the battery through the primary of the ignition coil to the stationary contact of the circuit breaker and thence to the moving member of the breaker to ground and back to the battery.

Directly over the circuit breaker is the high tension distributor. It comprises a Bakelite arm mounted on top of the rotating shaft and provided with a brass strip which is absolutely insulated from the shaft, but which is brought into contact with a carbon brush centrally mounted in the top of the Bakelite cover, by means of a light spring. The brass strip is so arranged that as the arm rotates with the shaft it is brought in close proximity with a series of contacts, mounted in a circle around the Bakelite cover, one contact for each cylinder of the motor. The metal strip does not actually touch these contacts, so that there is no wear, but the gap which separates them is so small that even a weak spark has not the slightest trouble in jumping it. There are some systems that have a sliding or positive contact in the distributor head.

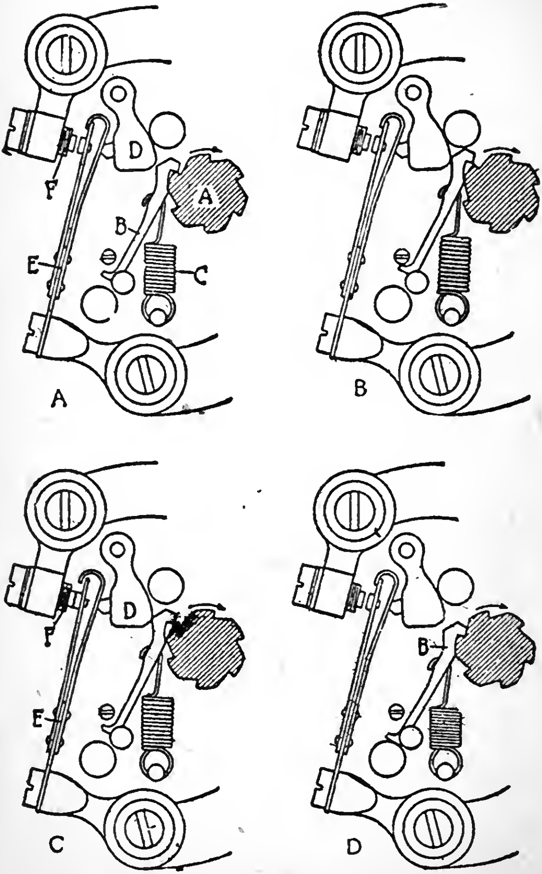
The central brush is connected to one of the secondary leads on the coil, the other lead being grounded. The cables from the other contacts lead each to the spark plug in the proper cylinder as determined by the firing order of the motor. As the shaft rotates, the arm is brought successively into juxtaposition with each of the contacts each time the cam mechanism comes into play making and breaking the circuit. The electrical surge which takes place in the secondary of the coil as a result of the making and breaking of the contact in the primary, therefore, is led to the central brush to the distributor arm, jumping the slight gap to the plug contact, through the cable to the spark plug. Here it

again jumps a gap to ground—ground being the metal of the cylinder—and back to the grounded terminal of the secondary completing the circuit. The next time the circuit breaker comes into play the arm has moved up and is in a position to send the spark to the cylinder next in firing order, and so on throughout the whole series of cylinders.

The operation of the open-circuit type of interrupter for the K3 type of battery ignition system, manufactured by the Atwater Kent Co., in brief, is as follows: Four different positions of the interrupter in one of its cycles of operation are shown in the accompanying sketch. The cam or ratchet, A, has as many notches as there are cylinders to be fired. The ratchet is mounted on the central vertical shaft of the device, which also carries the distributor, and in this combined form is known as a unisparker.

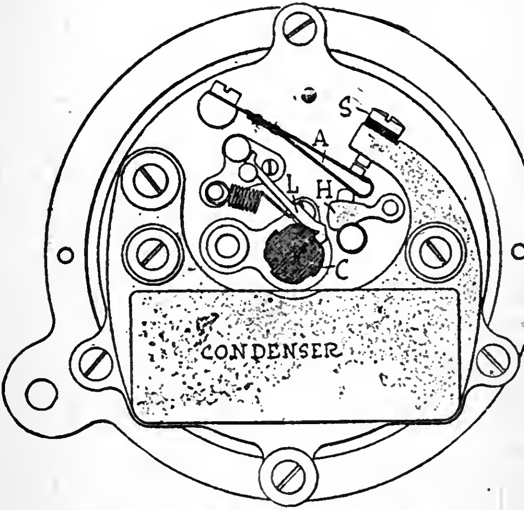
The ratchet A engages the lifter B and as A rotates, its teeth or notches successively tend to draw B with them against the tension of the spring C. In doing so the head of B strikes the swinging lever of hammer D, the motion of which in both directions is limited as shown, and the hammer communicates the blow to the contact spring E, bringing the contact points together momentarily. E is a compound spring, the straight member of which carries the movable contact, while the stationary contact F is mounted opposite it. The second member of this compound spring is curved at its end to engage the straight member. Ordinarily, the straight spring blade is held under the tension of the curved blade and the contact points are held apart.

When the curved blade is struck by the hammer D, the points come into contact with each other. The curved blade, however, is thrown



Diagrams showing operation of Atwater Kent interrupter.

over further by impact and its hook leaves the straight blade. Upon reaching the limit of its movement, it flies back and strikes the end of the straight blade a blow, causing a very sharp break of circuit. This movement is so extremely rapid that it cannot be detected by the unaided eye, so that its working cannot be tested simply by watching the operation of the contacts, as in the case of a magneto interrupter. The diagram shows the successive movements of the parts



Location of condenser in Atwater Kent open circuit breaker.

during a single cycle. In A a notch of the ratchet has engaged B and is drawing the lifter against the tension of the spring.

In the second sketch, B, the hook is just being released. It will be seen that the lifter is so shaped that with the hook in the notch of the ratchet the cam head of the lifter does not touch the hammer so that on the outward movement

of B no contact is made. In C, the lifter is riding back over the rounded portion of the ratchet and is striking the hammer D, which in turn pushes E for a brief instant against F. The return of B to the position shown in sketch D is so rapid that the eye cannot follow the movement of the parts D and E, which, to all appearances, remain stationary.

Adjustment of the contact points is made by removing one of the three washers from under the head of the contact screw F, and the gap should be .010 to .012 inch, never exceeding the latter. Where more accurate means of determining this distance are not available, it may be gaged with a piece of manilla wrapping paper, which should be perfectly smooth. With the aid of a micrometer, a sheet of paper of the proper thickness can be selected. The contact points are of tungsten, and, as the moving parts all are of glass-hard steel, very accurately machined, the wear is negligable, so that the adjustment is not required oftener than once in, perhaps, 10,000 miles, and replacement of contacts after running, perhaps, 50,000 miles.

In the latest models of this K3 type of ignition system, the condenser is located within the timer-distributor and in very close proximity to the contacts. This location of the condenser is shown in another diagram. An automatic spark advance mechanism is provided, which operates by centrifugal force, and this automatically advances the time at which the contact is made and broken to compensate for the increase in speed of the motor.

CHAPTER XII.

The Starter-Lighter System Analyzed.

A Little Study Reveals That the Electric Starting, Lighting and Ignition System Is Quite Simple—Chart Which Aids in Trouble Tracing and Correction.

PERHAPS taking the car as a whole, there is no one system incidental to its correct functioning that is so little understood as the electric lighting and starting system. To most owners, even to motorists of experience who know what each and every part of the car is for and just how to care for it, the starting and lighting system remains as a closed book.

Yet the system is simplicity itself, and what appear on the surface to be intricacies, dissolve into thin air once the light of reason is turned on this, the most happy of all conveniences that has been applied to the modern automobile.

The starting system, taken as a whole, comprises three units, and no one of the three is more important than the other. Each is essential to the correct functioning of the complete system. The first unit is the dynamo or generator, the purpose of which is to convert some of the power of the engine into electrical energy a portion of which is used to light the lights, some to start the engine, and in some cases a portion to furnish the ignition current. As the dynamo is nothing more nor less than an electrical "pump" which pumps electricity instead of water or air, and as it receives its necessary power from the engine, it is quite evident that when the engine is not running, the dynamo is worthless as a current producer.

That fact, therefore, necessitates the use of some sort of a device to store up the current generated when the engine is running for use to start the motor, supply the lights and ignition when the engine is inoperative. That function is performed by the "storage battery," which it can be seen is no less important than the current generator itself.

In order to turn the engine over a sufficient number of times for it to take up its own cycle of operations, a third unit, called a starting motor, is provided. It takes the current that has been stored up in the storage battery and reconverts it into mechanical energy which is utilized to spin the engine through the intermediary of a train of gears or a silent chain. Without the starting motor, there would be scant use for the other two units.

As for the dynamo: It comprises a number of coils of wire closely wound upon a slotted soft iron core which is rotated at high speed by the engine in a suitably shaped space between the poles of two electro magnets. Provision is made by means of a commutator, or rotary switch mounted on the shaft, to so connect the coils of wire on the rotating member or "armature" as to turn part of the current generated in them through the coils on the electromagnets or "field coils," thus increasing their strength; the remainder of the current goes to the battery or lamps, as the case may be. As the amount of current generated depends almost directly upon the speed with which the armature is rotated by the engine, provision is made by means of a regulator of one sort or another to cut down the current at high engine speeds and thus keep the output constant so that the lights will not flicker and the charging rate to the battery will not run too high and result in "gassing."

While there are as many different types ot regulators in use as there are makes of automobiles, for the most part regulation is effected by decreasing the amount of current passing through the field coils at high speeds. In some cases this is accomplished by inserting a variable resistance, or "current brake," in the field circuit so that the higher the rate of speed the harder it is for current to pass through this "brake" and consequently the less that will flow.

The system that has found most favor in this country employs a vibrating reed, much like the common "buzzer" which summons the housewife to the kitchen door. This is placed so that when it "buzzes," the parting contacts open the field circuit. The circuit of the operating magnet is connected so that it gets the full benefit of the dynamo current. At low speed, the buzzer does not operate, but at high speed it begins and intermittently introduces resistance into the field circuit and cuts down the field circuit. The faster the car goes the faster the buzzer vibrates and the greater the resistance. Hence the current is kept practically constant.

Another system uses an iron wire coil which heats up when current passes through it. At high temperatures, any further increase enormously increases the resistance of the iron. When the current gets strong enough to heat the iron coil beyond this critical temperature, therefore, it is automatically choked and cut down.

There is another little device which is of the utmost importance. It is the automatic cutout which is placed in the circuit between the dynamo and the battery and which serves to disconnect the two when the dynamo is not running. This prevents the battery current from running back through the dynamo and being wasted. This device consists simply of an electromagnet con-

nected in the circuit, the armature being normally held away from the magnet by means of a spring. In this position the circuit between the dynamo gets under way, however, at a predetermined point the pull of the magnet due to the current passing through it is sufficient to overcome the opposition of the spring and the armature of the magnet is attracted and closes the circuit. Quite as a matter of course, when the speed falls off and the current strength drops, the spring again pulls the armature away thus opening the circuit.

The popular idea in connection with a storage battery is that when a current of electricity is passed through the storage battery, that the current is "stored" in the battery. This is not the case at all. A "fully charged" battery does not contain any electricity. What actually takes place is this—when a current is passed through the battery certain elements in the storage battery plates are combined with the solution or electrolyte in the battery by a purely chemical process. This is why the hydrometer reading of the solution in a fully charged battery is much higher than that of a discharged battery, because the solution is heavier, having in it some of the elements which were in the plates of the battery before the charging took place. When the battery is discharged the action which takes place is that the chemicals in the solution or electrolyte are again combined with the plates in the storage battery, through another chemical action, and that is the reason why the hydrometer reading on a discharged battery is materially lower than that on a fully charged battery. As mentioned, there is no electrical energy stored up in the storage battery when it is charged. The current which is taken from a fully charged battery is generated through the chemical action described, and is

generated only at the time it is being taken from the battery.

When a battery is charged certain elements in the solution are constantly striving to again combine with the elements in the plates, or to return to the condition which they were in before the battery was charged. This explains the reason for the storage battery gradually discharging itself when it is not in use.

On the other hand when a storage battery is discharged, if it is left in that condition it will ruin itself in a short time. This is due to an action called "sulphating."

A storage battery will last longer and can be kept in good condition most easily when it is in constant use, that is to say, when it is being charged and used and recharged right along. A writer once described a storage battery very aptly when he said it was "a nervous proposition" and that it needed constant "excitement." This is really the situation in a nutshell. To keep your storage battery in good shape it should be kept in service.

To all intents and purposes, the starting motor is quite identical in principle to the dynamo. It comprises a wirewound rotating armature, positioned between the field pieces, and also has a commutator. As a matter of fact, practically any dynamo can be used as a motor, or vice versa; but because of their different uses, some slight alterations have been made in the machines which distinguishes the one from the other. The starting motor, for instance, is wound with much coarser wire than the automobile dynamo, the reason being that it must develop a great deal of power and to do that needs a whole lot of current. Fine wire would burn out under the strain. The dynamo, on the other hand, goes on

pumping only a small amount of current and does not need heavy wire.

In some instances, the function of both dynamo and starting motor are combined in a single instrument which is then called a motor-generator, and such a system is designated by the automobile maker as a "single unit" system as against the "two unit" system wherein dynamo and starting motor are each separate units.

The following tabulation will be found useful in determining when the electric starting and lighting system is at fault and locating troubles:

SYMPTOMS OF TROUBLE.

The Causes of Troubles can be Determined by a Study of Symptoms.

Ammeter does not indicate "Charge" engine speeded up, but indicates "Discharge" when lights are turned on, engine at rest.

Dynamo or regulator not working properly.
Dynamo brushes do not make firm contact with commutator.
Dynamo belt too loose to drive dynamo at proper speed.
Car speed too low.

Ammeter does not indicate "Charge" lights off, engine speeded up, and does not indicate "Discharge" lights on, engine at rest.

Open or loose connection in the battery circuit or in battery itself.
Battery terminals not securely connected.
Dynamo terminals loose.
Ammeter may be at fault.

Ammeter indicates "Discharge" lights turned off, engine at rest.

Ammeter pointer bent.
Insulation on wires injured, permitting contact with frame, causing short circuit.
Cutout not operating properly.

Ammeter indicates "Charge" engine at rest.
Pointer bent.

Ammeter "Charge" indications below normal.

Dynamo speed low.
Regulator not functioning properly.
Excessive lamp load.
Commutator dirty.
Generator defective.

Ammeter "Charge" indications above normal.

Regulator not functioning properly.
Short circuit in battery or in charging circuit.

Ammeter "Discharge" indications above normal, engine at rest.

Lamp load excessive.
Lamp wires in contact with frame.
Regulator cutout points stuck.

Ammeter pointer jerks intermittently from "Charge" to Neutral while engine is speeded up.

Short circuit in system.
Loose connection in dynamo circuit.
Brushes making poor contact.

Fuses blow repeatedly.

Lamp wires in contact with frame.
Lamps defective. Short circuited. Try new bulb.

Engine cranking speed very low.

Battery almost discharged.
Battery sulphated.
Engine stiff.
Starting cable not firmly secured to battery, starting switch, and motor.
Motor brushes making poor contact.

Starting motor does not rotate.

Battery may be discharged.
Battery may be sulphated or injured.
Starting switch not making good contact.
Motor brush may not make contact with commutator.
Battery terminals may not make firm contact.

Lamps will not light, but starter cranks engine.

Lamps burned out or filament broken. Try new bulb.
System short-circuited.
System open circuited.

Lamps seem to burn brightly but fail to illuminate road sufficiently.

Lamps out of focus.
Rays of light directed too far upwards.
Reflectors tarnished.

Lamps burn dimly or not at all.

Battery weak, discharged.
Lamps old, blackened. Try new bulbs.
System may be short-circuited.
Resistance of circuit high, due to loose or dirty wire connections.
Lamp bulbs may be of too high voltage.

Lamps blacken or burn out quickly.

Lamps not of the proper voltage.
Dynamo or regulator not working properly.
Lamps defective, poor grade.
Loose connection between generator and battery.

Lamps flicker and ammeter unsteady.

Loose connection in lamp wires.
Loose connection between battery and dynamo.
Loose contact at lamp connector or at lamp bulb.
Poor contact between fuses and fuse clips; fuse clips must securely clamp fuse ends.
Exposed wire touching frame intermittently, causing short circuit.
Lighting switch contacts burned.

Lamps burn very dimly or not at all when starting pedal is operated.

Battery very weak, almost discharged.
Battery injured, due to lack of water.
Battery cables not rigidly connected to battery or motor wiring.

CHAPTER XIII.

Operation of Eclipse-Bendix Starter Drive.

Simplicity of Important Unit Between Starter Motor and Engine Beclouds Its Action—Has Been Adopted by Most Starter Makers and Does Away With Hand Operated Devices.

ONE of the most important elements in the operation of any electric starting system is the mechanism which connects the electric starting motor to the engine when the latter is to be started, and disconnects it when the motor has taken up its own cycle of operations. Such a device is essential, for it is obvious that to drag a heavy starting motor would put an extra load on the engine and detract from its "snap" and pulling powers, while at the same time the starting motor, save in rare instances when it is built in a single unit with the dynamo, is not built for continued operation.

The first starting systems usually were provided with a shifting gear which was meshed with teeth on the periphery of the flywheel through the agency of a hand lever or pedal when the motor was to be started and thrown out of engagement again and when the engine began to fire. Arrangements of this sort still persist, but by far the greater number of starter manufacturers have thrown them into the discard and applied the Eclipse-Bendix drive. This little device automatically engages and disengages the starting motor at the proper times, without the slightest attention on the part of the operator and its almost universal application to starting systems makes a complete description of it, together with

a few words on its care, practically a necessity in a work of this kind.

The design of the Eclipse-Bendix Drive is so simple that at first it is hard to understand how it performs so many automatic movements and functions.

The device consists of a hollow shaft having screw threads on the outside, and a hollow gear having screw threads on the inside; so that the gear screws on the shaft like a nut on a bolt. A circular weight is fastened to the gear, and is slightly out of balance. A coil spring connects the electric motor shaft and the hollow screw shaft. (See Fig. 1.)

When the electric motor starts it drives through the spring and turns the screw shaft. Because of the weight the gear is too heavy to turn with the screw shaft, and because the gear does not turn it must move along the screw shaft (just the same as if you turned a bolt having a nut on it, and kept holding the nut with your fingers to keep it from turning so that it would be screwed along the bolt). After the screw gear has moved along the screw shaft and engages with the flywheel gear, it then keeps moving along until it reaches the stop at the end of the screw shaft. The two gears then are fully meshed, and it is obvious that when the screw gear has reached the stop it can not move any farther, and it then must turn with the screw shaft. (See Fig. 2.) At this particular moment the screw shaft and electric motor are revolving at a great speed, and this great blow and the power of the electric motor are both taken through the coil spring. The spring keeps coiling until all this power has been applied to the flywheel gear and the engine starts turning.

As soon as the engine starts exploding and runs

"IT'S AUTOMATIC"

Arrows Show Direction of Rotation

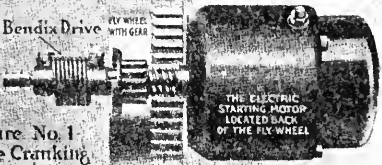


Figure No. 1
Before Cranking

Shows starter gear out of mesh and idle Now ready to be automatically screwed over into mesh with fly-wheel gear, when the electric motor is started

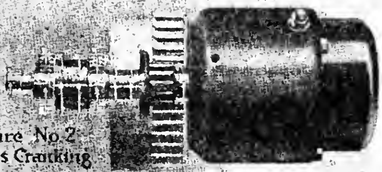


Figure No. 2
Starts Cranking

Shows gears after being automatically meshed and about to crank. The screw shaft is turning at over 1000 revolutions per minute and stores this terrific energy in the coiling spring before turning the fly-wheel and starting the engine.

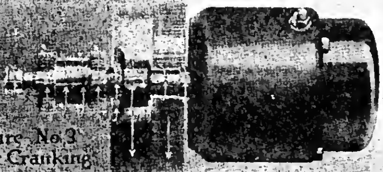


Figure No. 3
After Cranking

Shows starter gear after being automatically demeshed. It is now automatically clutching the screw shaft due to centrifugal action of the unbalanced weight.

under its own power, the flywheel, of course, turns much faster than it was cranked by the starter. Because it is now turning so much faster, it increases the speed of the screw gear so that the latter runs faster than the screw shaft on which it is mounted. It is, therefore, plain and easy to understand, that if the screw gear runs faster than the screw shaft, it will be screwed on the threads of the shaft (like a nut on a bolt) until it has been screwed out of mesh with the flywheel gear.

This demeshing movement is entirely automatic, and eliminates the use of an overrunning clutch. And now that the screw gear is out of mesh, it is natural to suppose, if the electric motor keeps running, that the gear will be automatically screwed right back into mesh with the flywheel gear. But the unbalanced weight on the screw gear now performs its automatic function. That is, being slightly out of balance, the weight twists or cocks the screw gear so that it clutches and binds on the screw shaft and turns with it. This automatic clutching is all due to the centrifugal force of the unbalanced weight. (See Fig. 3.)

When the electric motor stops running, the screw gear has been fully screwed away from the flywheel gear, and it remains in that retarded position until it is again required to start the engine.

The Eclipse-Bendix Drive should not require any care or attention during the life of a motor car.

The screw shaft should never be oiled or lubricated. It is not necessary—in fact, the screw gear works to best advantage when the screw shaft is dry.

Through accident or otherwise, should the flywheel ever be entirely exposed and unprotected,

and the flywheel gear possibly drag in wet mud, a slight inconvenience may result therefrom. But such a condition and operation of a car is, of course, unreasonable. The gear on the screw shaft has an automatic self-cleaning action, but, in any extreme case, it may then be necessary to clean the screw. Therefore, a slight inconvenience is the only penalty for such careless misuse of the car, by having it in such an unprotected condition.

Back fires are unnecessary, because the driver of a car should have the spark lever properly retarded, and the gas throttle should not be wide open, but should only be moved over enough for starting. With the spark and throttle levers only slightly advanced, back fires are avoided and the engine starts easiest and quickest. In case of a back fire, the explosive shock is taken through the coil spring, which absorbs most of the destructive blow, and is another automatic feature of the Eclipse-Bendix Drive. As an extra precaution against back fires the drive spring and drive screws are designed with large factors of safety.

The teeth on the screw gear and flywheel are chamfered or pointed on only one side, to make the meshing natural and easy. However, should the teeth meet end to end, the screw shaft itself is designed to automatically move backwards against and compress the coil spring. This gives the screw gear time enough to turn and enter the flywheel gear. Should sticking of gears ever occur, they can be released by throwing in the clutch and moving the car. Such trouble would be due to incorrect chamfering or inaccurate alignment of the gears. Also it might be due to the binding of the drive parts and prevent compressing and proper functioning. Such defects should be corrected.

If while the engine is running the electric motor should be accidentally started, the screw gear will, of course, screw over against the turning flywheel gear. But instead of the clashing and smashing of gears that might be expected, there is no damage whatever, as the gears simply touch once. This is because the flywheel gear will speed up the screw gear, and thus automatically screw it away. The turning screw gear will then automatically clutch and bind on the screw shaft in exactly the same manner as when it is cranking and has been demeshed when the engine starts exploding.

The Eclipse-Bendix Drive is guaranteed against defective material and workmanship. All parts are made of specially selected steels and properly heat treated. Every care is taken to give complete satisfaction.

CHAPTER XIV.

SUPREME IMPORTANCE OF BATTERY CARE.

Batteries Will Give No Trouble If Attended to Regularly and Properly—Full and Explicit Rules For Battery Care and Upkeep—The Rules Are Inflexible.

AS for the mechanical elements of the starting and lighting system, aside from occasional lubrication according to directions furnished by the maker, there is but little for the owner or driver to do, and nothing to worry about. Nor, with the exception of the storage battery, is there anything in the electrical end of the system that needs constant attention. The battery, however, does require a certain amount of attention which, if the best results are to be obtained, and freedom from trouble assured, must be done with the regularity of clock work.

And in speaking of the battery and battery care, there is one little point that must never be forgotten. Most rules and regulations are more or less flexible, but that is not the case with the storage battery instructions. They must be followed to the letter. A storage battery is an expensive and at the same time a delicate mechanism, and it does not pay to experiment with it. No one yet, barring accident, had trouble with a battery who was careful to follow the instructions laid down for its care to the letter. Now for the instructions.

1. Batteries must be properly installed.

Keep battery securely fastened in place.

Battery must be accessible to facilitate regular adding of water, and occasional testing of solu-

tion. Battery compartments must be ventilated and drained, and all water, oil and dirt kept out. Battery should have free air space on all sides, should rest on cleats rather than on solid bottom and holding devices should grip case or case handles. A cover, cleat or bar pressing down on the cells or terminals should not be used.

2. Keep battery and interior of battery compartment wiped clean and dry.

Do not permit an open flame near the battery.

Keep all small articles, especially of metal, out of and away from the battery. Keep terminals and connections coated with vaseline or grease. If solution has slopped or spilled, wipe off with waste, wet with ammonia water.

3. *Pure water must be added to all cells regularly and at sufficiently frequent intervals to keep the solution at the proper height.*

The proper height for the solution is usually given on the instruction or name-plate on the battery. In all cases the solution must cover the battery plates.

The frequency with which water must be added depends largely upon the battery, the system with which it is used and the conditions of operation. Once every two weeks is recommended as good practice in cool weather; once every week in hot weather.

Plugs must be removed to add water; then replaced and screwed home after filling.

Do not use acid or electrolyte, only pure water.

Do not use any water known to contain even small quantities of salts of any kind. Distilled water, melted artificial ice or fresh rain water are recommended.

Use only a clean, non-metallic vessel.

Add water regularly, although the battery may seem to work all right without it.

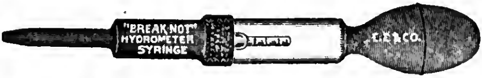
4. The best way to ascertain the condition of the battery is to test the specific gravity (density) of the solution in each cell with a hydrometer.

This should be done regularly.

A convenient time is at the time of adding water, but the reading should be taken before rather than after, adding the water.

A reliable specific gravity test cannot be made after adding water and before it has been mixed by charging the battery or by running the car.

A common and convenient form of testing the specific gravity of the electrolyte is with a hydrometer syringe. To take a reading insert the end of the rubber tube in the cell. Squeeze and then slowly release the rubber bulb, drawing up elec-



trolyte from the cell until the hydrometer floats. The reading on the graduated stem of the hydrometer at the point where it emerges from the solution is the specific gravity of the electrolyte. After testing, the electrolyte must always be returned to the cell from which it was drawn.

The gravity reading is expressed in "Points," thus the difference between 1,250 and 1,275 is 25 points.

5. When all cells are in good order the gravity will test about the same (within 25 points) in all.

Gravity above 1,200 indicates battery more than half charged.

Gravity below 1,200 but above 1,150 indicates battery less than half charged.

When battery is found to be half discharged use lamps sparingly until by charging the battery the gravity is restored to at least 1,200. (See section 8.)

Gravity below 1,100 indicates battery completely discharged or "run down."

A run down battery should be given a full charge at once.

A run down battery is always the result of lack of charge or waste of current. If, after having been fully charged the battery soon runs down again there is trouble somewhere else in the system, which should be located and corrected.

Putting acid or electrolyte into the cells to bring up specific gravity can do no good and may do great harm. Acid or electrolyte should never be put into the battery except by an experienced battery man.

6 Gravity in one cell markedly lower than in the other, especially if successive readings show the difference to be increasing, indicates that the cell is not in good order.

If the cell also regularly requires more water than the others, a leaky jar is indicated.

Even a slow leak will rob a cell of all of its electrolyte in time, and a leaky jar should be immediately replaced with a good one.

If there is no leak and if the gravity is, or becomes, 50 to 75 points below that in the other cells, a partial short circuit or other trouble within the cells is indicated.

A partial short circuit may, if neglected, seriously injure the battery and should receive the prompt attention of a good battery repair man.

7. A battery charge is complete when, with charging current flowing at the rate given on the instruction plate on the battery, all cells are gassing (bubbling) freely and evenly and the gravity of all cells has shown no further rise during one hour.

The gravity of the solution in cells fully charged as above is 1,275 to 1,300.

8. The best results in both starting and lighting service will be obtained when the system is so designed and adjusted that the battery is normally kept well charged, but without excessive overcharging.

If, for any reason, an extra charge to maximum specific gravity is needed, it may be accomplished by running the engine idle, or by using direct current from an outside source.

In charging from an outside source use direct current only. Limit the current to the proper rate in amperes by connecting a suitable resistance in series with the battery. Incandescent lamps are convenient for this purpose.

Connect the positive battery terminal (painted red, or marked POS or P or +) to the positive charging wire and negative to negative. If reversed, serious injury may result. Test charging wires for positive and negative with a voltmeter or by dipping the ends in a glass of water containing a few drops of electrolyte, when bubbles will form on the negative wire.

9. *A battery which is to stand idle should first be fully charged.*

A battery not in active service may be kept in condition for use by giving it a refreshing charge at least once every month, but should preferably also be given a thorough charge, after an idle period, before it is replaced in service.

A battery which has stood idle for more than two months should be charged at one-half normal rate to maximum gravity before again being placed into service.

It is not wise to permit a battery to stand for more than six months without charging.

In conclusion, it might be well to point out that with the first flurries of real winter, it is well for motorists to heed the "test your battery" advice. During the summer months the battery

is kept well charged because owners drive their cars sufficient to keep the battery in good shape, but in the winter months, with consequent less amount of driving, automobile batteries sometimes "run low."

The old adage of "an ounce of prevention is worth a pound of cure" certainly applies to the upkeep of automobiles, and if owners will give their batteries inspection, there is no occasion for it ever "going dead." Most owners are inclined to make necessary inspections, provided it can be easily done, and the car manufacturers have themselves to blame in many cases by having the part that needs inspection placed so that it is difficult to reach.

With a hydrometer (which can be had at a very nominal price) the owner can very easily test the conditions of each cell of his storage battery every week or so. This instrument merely gives, on an easily-read scale, the specific gravity of the liquid of each cell. The test is easily made, and from the reading of this specific gravity the owner may tell at a glance whether the battery is fully charged or is nearly exhausted. Thus, if he finds the battery is but partially charged, he may know that the lights and starter have been used without sufficient running of the car to replace the current consumed. This will furnish a hint to him to use the lights and starter sparingly until some extended daylight trip of several miles at a fair, average speed, will serve to restore the electrical reservoir to its normal level. This occasional testing of the storage battery, together with the addition of the required amount of distilled water to each cell every week or two, is the only work required of the owner of the average car to keep the heart of his starting and lighting system in proper condition.

CHAPTER XV.

Clutch Adjustments.

Detailed Directions for Increasing Tension, and Replacing Friction Discs on the Now Almost Universal Dry Disc Clutch.

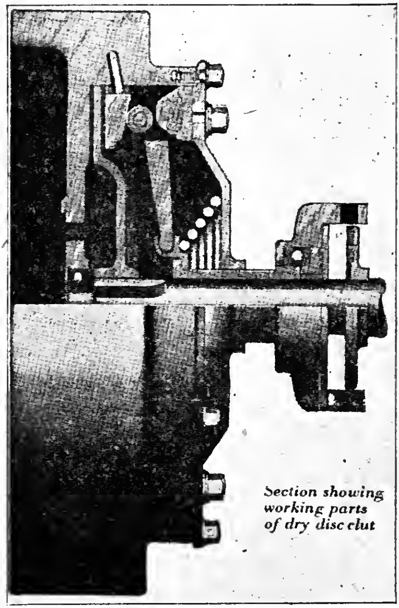
THERE are three essential clutch parts: the clutch spring to engage the clutch, the clutch pedal to disengage the clutch, and the friction surfaces whose duty it is to impart the power developed by the motor to the transmission. The friction units are the base of the flywheel, two Raybestos rings, the steel friction disc and clutch thrust ring. These are so arranged that there is no metal to metal friction, but a very positive pickup with the Raybestos acting as a cushion.

While the Raybestos rings are subjected to a great amount of usage, and abuse, in some cases, they wear but slightly. When they do wear, adjustment can easily be made by loosening the top two screws, which may be seen by removing the clutch cover plate and turning the motor over slowly until they come into view. Adjustment is made by tapping them in a clockwise direction, a half inch or so, and retightening them. When the limit of adjustment for the first setting is reached, you will note that a new hole tapped for a cap screw will appear at the left end of the slot. You can then remove the cap screws, one at a time, and insert them. You will then have another complete range of adjustment.

When it is no longer possible to secure adjustment, new Raybestos rings should be installed and the cap screws replaced in the holes they were in before changing to the second range

of adjustment. This is necessary only after the car has been driven for a good long mileage. New Raybestos rings may be installed by any owner of average mechanical ability by following the complete instruction given below:

Remove the drive and pedal shaft, then loosen cap screws and drop the transmission, which will



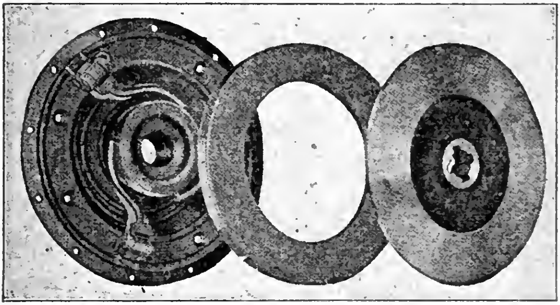
Section showing working parts of dry disc clut

give you access to the actual mechanism. Slip two pieces of wood, approximately an inch thick, one under each of the projecting lugs, which fit into the shifting yoke; then loosen the cap screws which hold the clutch cover plate in place. Be very sure to see that the blocks are placed under these lugs before you loosen the cap screws.

You can now remove the units which are at-

tached to the clutch cover plate and lay them to one side. It is now necessary to pull out the clutch thrust ring, then take off a plate at the top of the clutch housing and drive out the three dowel pins which fit in the notch cut in the thrust ring, with the aid of a drift punch. To do this, it will be necessary to turn the motor over by hand in order that you may have access to each of them. When these are removed, you can take out the first Raybestos ring and the friction disc; then the second Raybestos ring.

You are now ready to insert the first new ring,



The Clutch Disassembled.

then the friction disc, which must be absolutely free to move on the shaft, then the remaining Raybestos ring and dowel pins. Next comes the thrust ring, which must be perfectly free to move forward and backward. If it does not, you will probably find that the dowel pins, which are cut so that the heads will allow freedom of motion, are not properly set. This means that you must turn them until this position is reached.

Next take up the clutch cover plate and examine it until you find an "X," which is an indication that the holes for cap screws which are spaced closer than the remainder. Next, locate

the two close holes in the flange of the flywheel and insert the cap screws which hold clutch cover plate in place, being sure that the clutch crank thrust rollers are so turned that the flat side is against the thrust ring. As the wood blocks under the lugs of shifter collar have probably dropped out, you can now raise the transmission and insert clutch shaft.

There may be some little difficulty on the part of an inexperienced man in getting this shaft in proper position, but after a few trials it will be found to shift readily enough into place. With the aid of a pinch bar, force the lug of the shifter collar into the proper position in the clutch and throw out the yoke. Then, with one end of the pinch bar on the flywheel, and extending through opening in clutch housing, pull up, not too hard, and the parts will slip into proper position, which will permit the cap screws, which hold the transmission, to be inserted properly.

In case the cover plate has been removed from the adjusting ring, care must be taken to replace it in the proper position. Since the bell crank levers are at thirds and the adjusting screws are at halves, a half turn from the proper position will make adjustment of the clutch impossible. In the cover plate, there is one hole that the cap screws go through to hold it on the flywheel, which is spaced differently from the rest. Below this hole will be found the "X" referred to and one of the bell crank thrust rollers must be placed directly opposite this "X." With this properly placed the bell crank thrust rollers will be in contact with a point on the thrust ring at the thinnest point of the ring when the clutch cover plate is placed and bolted to the flywheel.

CHAPTER XVI.

Functions of Automobile Transmissions.

Why Some Sort of Speed Reducing Mechanism Is Needed Between Motor and Rear Axle—Various Types of Motor Car Transmissions Described and Explained.

WITH every gasoline engine it is absolutely necessary that some method be used for changing the relation between the speed and power of the car. When a gasoline engine is loaded above a certain limit it slows down, and the intervals between the explosions in each cylinder become so far apart as to cause the engine to labor and finally stop altogether, unless some means is used to increase the speed of the engine by decreasing the load upon it. In considering this subject it must be remembered that when a car is using its maximum power, it may be divided, either into considerable pulling power with slow speed, or high speed with low pulling power. Consequently, when a car is going at high speed and a considerable grade or a stretch of heavy road is encountered, the car will begin to slow down until the speed reaches such a point that the engine begins to knock and labor. When this point is reached, it becomes necessary to change to a lower gear, which, for the same speed of the vehicle, gives a considerable larger number of revolutions of the engine with a consequently larger pulling power.

This pulling power is termed "torque," and if gasoline engines could be so designed as to afford an increasing torque with decreasing speed all would be well and the transmission could be elim-

inated. As it is, taking into account the power of the motor at several speeds, nothing of this sort can be considered. At very low speeds the torque becomes of greatest importance.

The use of the transmission is also necessary in starting the vehicle, because, until it reaches a certain momentum, there is a considerable load on the engine, so that a lower gear which allows a higher number of revolutions of the engine must be used.

It is generally understood that to reverse motion of the automobile motor is to labor under disadvantages in numerous ways. Power will be

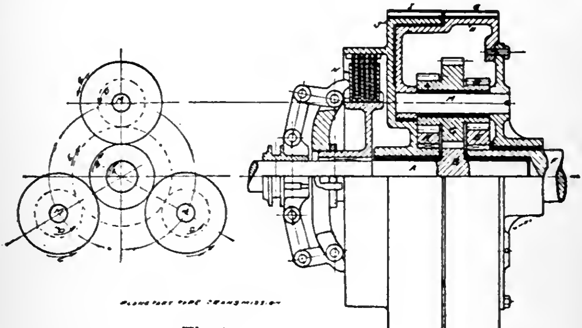


Fig. 2.

lost owing to the inferior valve timing relation, which must follow if the camshaft is designed to suit reversing conditions.

Unless certain complications are introduced in the valve action and since in any case it would be necessary to add to the flexibility of the motor by the use of a transmission, it would seem unnecessary to add to the valve motion anything in the way of complicated devices. An addition to the gear set is less complicated and the end is adequately served.

The most popular types of transmissions are the planetary and sliding gear types. The planetary with few exceptions, is only used on the light vehicles, while the sliding gear type is extensively used on all sizes of vehicles.

The planetary transmission is somewhat cheaper to manufacture than the sliding gear type and also requires much less skill in its operation. There are two types of planetary gears, those comprising internal and external gears and those comprising only spur gears in their make-up. The latter type is the most popular and will be considered in this article.

Fig. 2 illustrates this type of transmission and its principle of operation may be described as follows:

The driving shaft "A" carries the driving pinion "B" which meshes with planetary pinions "C." The latter forms part of the sets of three pinions which are formed integral. "D" is the low speed planetary pinion meshing with the low speed gear "E," which is secured to the driven shaft "F." By applying the brake band "G" to the combined pinion carrier and drum "H," the planetary pinions are held stationary in space and act like a back gear. Pinion "B" rotating right-handed turns pinions "C" and "D" on their pin "M" left-handedly, and pinion "D" turns gear "E" and the driven shaft "F" right-handedly, that is, in the same direction as the driving pinion "B."

For reverse brake band "I" is applied to the brake drum "J" which has the reversing pinion "K" keyed to it, being thus held stationary. When pinion "B" is rotated by the engine, planetary pinion "L" is forced to roll on "K" in a right-handed direction, carrying the pinion pin "M" and pinion carrier "H" with it, thus reversing the direction of the motion of driven shaft "F."

Direct drive is obtained by engaging the high speed clutch "N," which locks the reversing gear "K" to the driving shaft "A," and since two equal gears "B" and "K" are now secured to the shaft "A," the planetary pinions are locked against axial motion and the whole transmission revolves as a unit.

The sliding gear type of transmission consists of two parallel shafts mounted on suitable bearings in a housing called the transmission case. The first of these shafts is known as the primary or main driving shaft. This shaft is divided into two parts, the forward or driving end, and the rear or driven end, the latter being provided with a bearing at its forward end inside the former. The second of these shafts is known as the secondary or countershaft. The driven part of the main shaft is either squared or provided with integral keys and carries the sliding gears, whose common hubs have squared holes or keyways to coincide with the driven shaft to make a sliding fit upon it. The driving part of the main shaft is provided with a gear which meshes with a gear on the countershaft and forms a drive for the latter. This countershaft has a number of gears fixed upon it, depending upon the number of speeds. The gears on both shafts are so spaced that shifting the primary set, corresponding gears on the two shafts can be brought into mesh successively without interference from the other gears. Shifting of the sliding set is accomplished by means of a hand lever located conveniently to the operator and a suitable connecting linkage. The shifter rod carries a fork which is attached to the sliding gears in such a manner as to permit them to rotate with the shaft.

There are two common arrangements of shafts. In some cases the countershaft is located below

the main shaft, while in others the two shafts are located in a horizontal plane.

When the shafts are placed vertically the case is generally cast in one piece with a large hand hole cover plate for inspection purposes. Where the shafts are placed in a horizontal plane, the case may either be cast in one piece or in halves, joined through the centers of the bearings.

There are three general methods of mounting the transmission.

1. Combining it with the motor to form a unit power plant.

2. Individual mounting on a sub frame or cross members.

3. Combining them in a unit with the jack shaft for chain drive and with the rear axle for shaft drive.

All of these mountings may be made with a more or less degree of flexibility. Three point support is most generally resorted to, so as to relieve the unit of stresses set up by frame weavings.

Fig. R depicts a three speed forward and reverse selective sliding type of transmission. The primary shaft is squared and carries the two sliding gears, which are shifted by independent shifter rods. The countershafts are driven through constant mesh gears "A" and "B." In effecting the different speeds, gear "C" is moved forward and meshed with gear "D" for low speed, while for reverse it is moved backward and meshed with the reverse pinion "E," which remains in constant mesh with the reverse gear "H" on the countershaft. For second speed the gear "F" is meshed with the gear "G," while for high speed gear "I," which is integral with gear "F," is moved forward and meshed with the internal gear formed integral with the constant

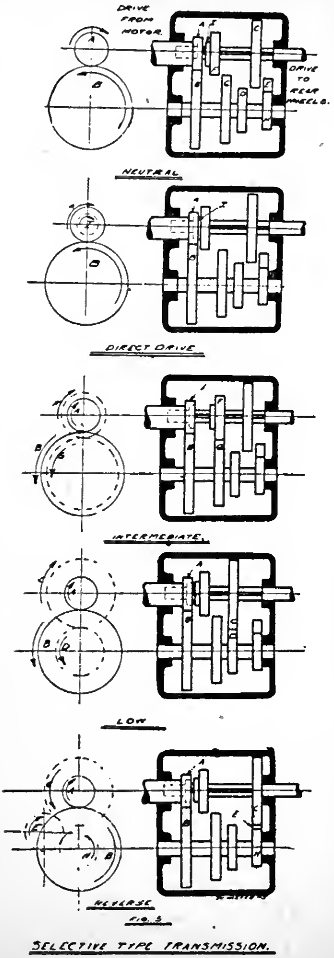

DRIVE FROM MOTOR.
DRIVE TO REAR WHEELS.
NEUTRAL
DIRECT DRIVE
INTERMEDIATE.
LOW
REVERSE
FIG. 5
SELECTIVE TYPE TRANSMISSION.

Fig. R.

mesh gear "A." This forms another type of jaw clutch, while the type depicted above may also be used for effecting the high speed. The drive and speed reduction for first and second speed and reverse is through the constant mesh gear and the sliding gears which are meshed, being similar to the progressive type.

The positive clutch type of transmission is related to the selective sliding type, since it operates on the selective principle. However, the gears remain constantly in mesh, and the gears on the main shaft are normally free to turn thereon, but may be fixed on their shafts by positive clutches. These clutches may either be of the jaw type or internal and external gears as mentioned above. The gears on the main shaft are fixed against axial motion, while the clutches are free to slide upon keys or a squared portion of the shaft.

In this type, as mentioned, the speed changes are obtained by meshing the clutches, and Fig. 5 will serve as an illustration for this type; however, the high speed is direct, and since the reduction between all gears is different, a provision must be made so that the countershaft can be disengaged when high speed is used.

Transmission gears are usually lubricated by a non-fluid oil. For easy introduction of the lubricant, a hole is provided in the cover plate or upper half of the case, while the case or lower half is provided with a drain plug, so that the stated lubricant may be washed out with kerosene or gasoline. The bearing caps are invariably provided with felt washers, while all other parts are provided with paper gaskets to prevent the lubricant from working out of the case.

CHAPTER XVII.

REAR AXLE TECHNOLOGY.

Sidelights on the Construction of the Most Important Element in the Running Gear which Every Car Owner or Expectant Car Owner Should be Familiar With.

FROM the standpoint of safety the rear axle is almost as important a part of the motor car as the front axle. From the standpoint of the many things it has to do it is even more important.

It must support more than half the weight of the car and its load. If it should fail to perform this or any one of its three other functions there would, of course, be no motor car.

It is the part which gets the least attention and which is least understood by the average owner. Yet it must perform its functions without a hitch every time the car is taken out on the road.

Owners will get more power from their engines, more comfort and satisfaction from their driving and will be more secure when they better understand the rear axle and give it more intelligent care.

In the water an article either floats or sinks. And technically speaking, a rear axle is either "floating" or "non-floating." The terms "semi-floating," "three-quarter floating" and "seven-eighths floating" are really misnomers and should not be used.

In the floating type the housing sustains the load and prevents wobble of the wheels while the axle shafts "float" within the housing and merely transmit the turning power from the differential to the wheels.

In any but the floating type the axle shafts, beside turning the wheels, play some part in preventing wobble and therefore absorb some additional strains.

Tendency to wobble is caused by side pressure on the wheels. Engineers call this side pressure "skidding force," because the familiar skidding against a car track or curb pictures most clearly

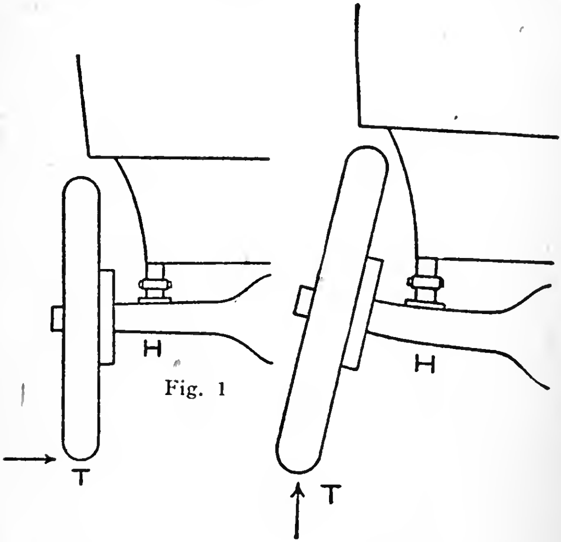
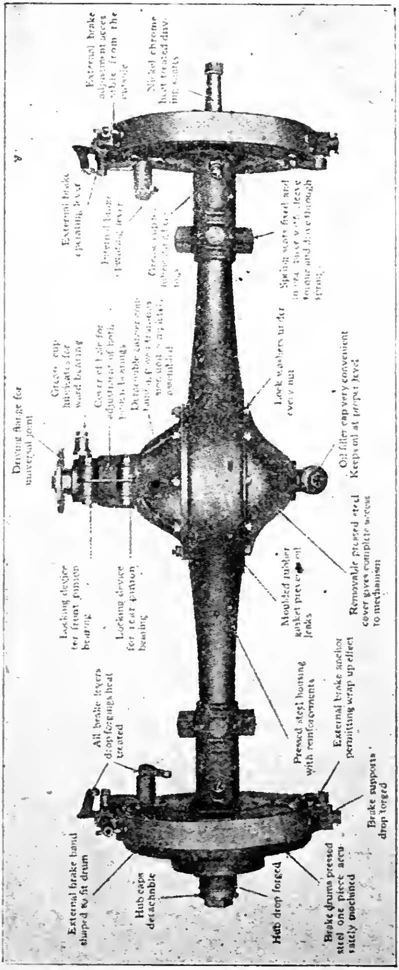


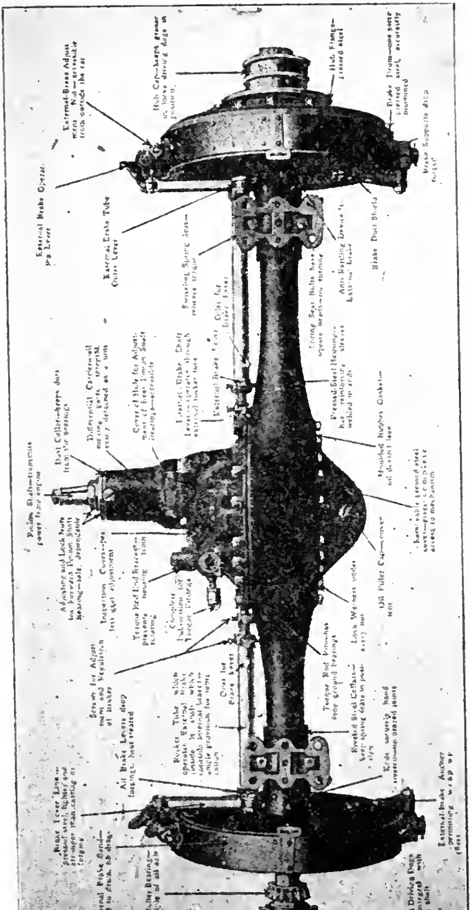
Fig. 1

the side pressure on the wheels that is ever present in degree and is due to uneven pavements, to ruts and to turning corners. Rear axle design would be quite simple if the car always moved straight ahead over perfectly smooth roadways. Mere downward pressure of car and load; mere turning of wheels would require no great engineering ability.

Side pressure or skidding force may on occasion be five to ten times as great as vertical force.



Timken-Detroit Fixed Hub Type Rear Axle.



(And axle engineers always have to take these occasions into consideration in their designs.) Skidding force is the greatest force to be considered in axle design.

Now, to understand the essential differences in the various rear axle types, let us consider the combined action of skidding force and downward pressure. For simplicity we can overlook the turning force because it is the same in all axles;

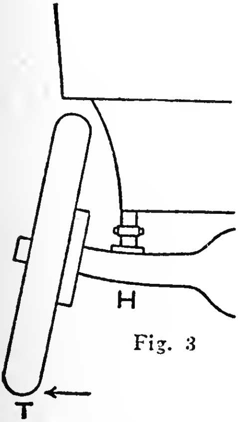


Fig. 3

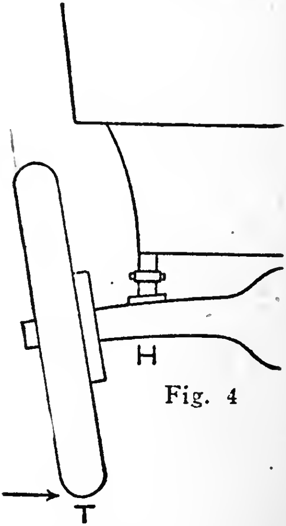


Fig. 4

and as both halves of the axle are alike we can consider the force in one-half only.

Note in Figure 1 that the weight of car and passengers is a force pressing down at "H." There is, of course, a reaction of equal force pressing up at the ground "T." These equal forces are called static load. The skidding force acts at "T" in the direction of the arrow—or in the exact opposite direction.

The static pressure tends to spring the axle as

shown in Figure 2. The skidding force tends to spring the axle as shown in Figure 3 or Figure 4, depending upon the direction of that force. Bear in mind that the axles do not really spring out of shape as shown in the illustration. The drawings merely indicate tendencies which correct engineering design prevents from becoming actualities. Tendencies in engineering parlance are called stresses.

Thus it is evident that both static force and skidding force create bending tendencies or stresses in the axle. It is the combination of the forces of weight and skidding when acting together to produce the same tendency as in Figure 2 plus Figure 4 that determine the maximum stresses engineers must figure in designing a safe rear axle.

Because "H" is 5 to 10 inches from the center plane of the spokes there is some bending stress set up by the static force. And as there is a considerably greater distance (half the diameter of the wheel, i. e., 16 to 19 inches) from the ground "T" to the center line of the axle, there is a much greater bending stress added by the skidding force.

In the "full floating" type of axle, Figure 5, all the bending stress due to static force and skidding force is carried by the housing. The driving shafts turn freely within the housing and bear only the "torque" or stress of turning the wheels. The shafts are said to float within the housing.

In the "semi-floating" type, more properly called the "fixed hub" type, see Figure 6, the driving shafts turn freely within the housing. At their outer ends they are fixed in the hubs of the wheels and carry the bending stresses as well as the torque.

In the "three-quarter floating" Figure 7 or bet-

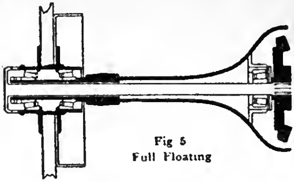


Fig 5
Full Floating

ter the "flanged shaft" type, the housing extends into the hubs of the wheels as in the "full floating" type, but the ends of the driving shafts are connected rigidly by flanges with the wheels so that the shafts take almost all the bending stresses and all the torque. In the flanged shaft axle,

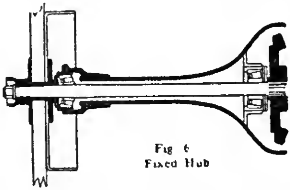


Fig 6
Fixed Hub

especially when only one bearing is used under the center of the wheel, the stresses are quite similar to those in the fixed hub type. We will therefore confine our further study to the full floating and fixed hub types.

It will be seen by a glance at Figure 5 that the

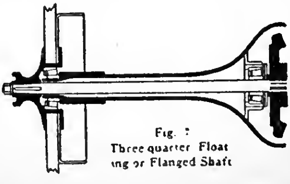


Fig. 7
Three quarter Floating or Flanged Shaft

preventives of bending in the full floating are the two bearings located fairly close to each other. A glance at Figure 6 will show that the preventives of bending in the fixed hub types are the two bearings located nearly half the car's width apart.

Everyone knows that when the supports are far apart they offer a much greater resistance to bending stress.

In the full floating axle the shafts can be more easily removed for repairs. This is an advantage on rare occasions. Either type will give as satisfactory service as the other if each is properly proportioned for its work. But it is necessary to make the full floating somewhat heavier than the fixed hub type for the same capacity.

Time was, with all axles, when oil from the differential used to work along the live axles, leak out through the hubs and get into the brake-linings.

Time was, when it stained the wheels, ran down the spokes and injured the tires.

Then somebody said, "Why not run a sleeve into the central opening in the differential housing, just to make pockets that will retain the oil?" Why not?

And that's what was done. The oil is thrown to one side by centrifugal force when the car rounds a curve. The pocket catches the oil and holds it—all of it—till the car goes straight and gravity returns it to the differential. Oil doesn't get to the brake-lining; it stays where it's needed, in the housing.

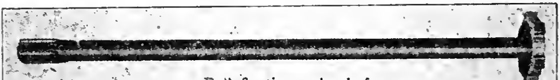
It isn't merely the size or rated horse power of the engine that counts. It's the power that gets to the rear wheels which moves the motor car. And all this effective power must go through the more or less intricate mechanism of the rear axle. The slightest deviation of a shaft from the correct line—the slightest inaccuracy in the meshing of the gears—puts additional strain on the engine; increases fuel cost; diminishes satisfaction.

The engine turns the propeller shaft rapidly at right angles to the wheels. In the rear axle this power must turn a corner toward each rear

wheel; it must be divided so that each wheel gets an equal share no matter if one travels faster that the other when rounding a curve; and the number of revolutions per minute must be reduced so that the wheels will not revolve as rapidly as the propeller shaft.

Making the power of the engine turn the corner and reducing the rate of rotation of the wheels are both accomplished by the use of a bevel pinion and bevel ring gear, or of a worm and worm gear.

Bevel gearing is the commonest means for turning the power and reducing the motion in the gasoline passenger car. The most recent advance in bevel gear construction is the introduc-



Full floating axle shaft

Fixed hub axle shaft

tion of the helical bevel, the teeth of which are curved instead of straight.

In a straight tooth bevel gear any given tooth goes into or out of mesh at one time along its entire length. In the helical bevel, however, the meshing starts at one end of the given tooth and gradually moves toward the other end. The same is equally true of the demeshing.

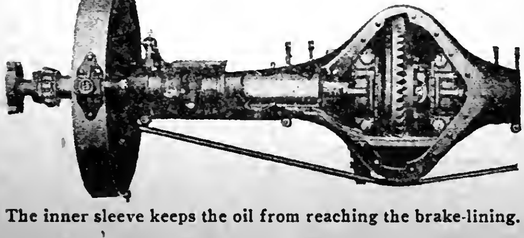
On account of this action at least two helical teeth are in partial mesh all the time. It is this feature of *gradually* entering and leaving mesh that insures no pound, click or chatter of gears as they revolve in the axle.

And the principle works as well when the gear and pinion are old and somewhat worn after thousands of miles of hard service as when they

are first assembled. Accurate tests show that the helical bevel is fully as efficient under all conditions as the straight bevel.

Inside the big driving-gear is the differential. The object of the differential is to so divide the power received from a single source (the driving-gear) that it will apply at all times with equal force to the two rear wheels and yet allow one wheel to rotate faster than the other as required when turning a corner.

From the differential the power is carried to the wheels by the axle shafts. They must be



The inner sleeve keeps the oil from reaching the brake-lining.

strong—strong enough to resist the greatest possible torsion under any conditions of travel. Yet they should be as light as is consistent with perfect safety. Where the shaft enters the differential it is enlarged, the end is splined—and steel is left back of the spline—a very important matter. At its wheel end the shaft of the floating axle is enlarged to form an integral disc or "driving dog" which fits into the driving plate of the hub and turns the wheel.

Because the shaft of the fixed hub type axle takes both torque and bending stress it is not of uniform diameter throughout the entire length. It is made thickest where stresses are greatest and one diameter tapers gradually to another diameter to avoid shoulders which would concentrate the stress.

The flanged portion of the brake-drum rotates between two brake-bands, and when the levers are pulled they contract the external band or expand the internal one, as the case may be.

The surfaces of a brake-drum are accurately finished in order that the brake bands or "shoes" may take hold with equal force at every point. Even the brake-lining itself is inspected and tested and must not vary in its dimensions more than a thousandth of an inch.

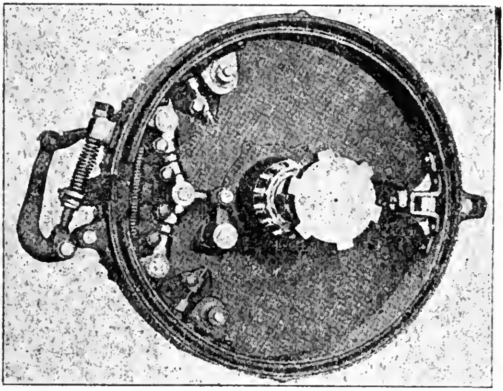
Torque and Driving Stresses.—The rotation of the pinion at the axle-end of the propeller-shaft causes the driving-gear with which it meshes and the differential axle-shafts and wheels to revolve, thereby moving the car.

At the moment of starting, the inertia of the car and the traction of the wheels on the ground tend to prevent these parts from rotating. This produces a great pressure between the parts, and that pressure comes full force between the teeth of the driving pinion and those of the driving gear.

In starting the car forward, since the driving gear is momentarily stationary, the driving-pinion tends to climb up on the gear and in climbing to carry with it the propeller-shaft and the forward part of the housing through which it projects.

In short, the entire housing tends through this pressure to rotate in a direction exactly opposite to that in which the wheels are turning.

While this tendency to rotate the housing is



Timken Toggle Brake.

perhaps greatest at the time of starting the car it is also present at all times when the car is in motion, particularly when the wheels meet extra resistance as in sand or mud and when obstacles are struck.

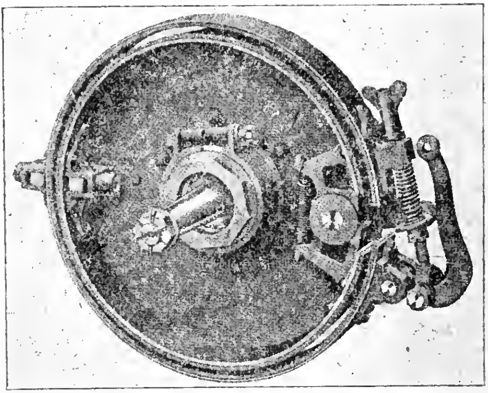
It is necessary to prevent the housing from rotating and to absorb the stress caused by the tendency to rotate, which stress is called "torque."

Rotation of the wheels against the ground forces the axle forward. This "driving force" must be transmitted from the axle to the chassis.

It is becoming more and more the general prac-

tice to take both the torque and the "drive" through the springs, particularly in the lighter cars. With properly designed springs this plan is entirely practicable, simplifies the construction and lowers its cost somewhat. It gives greater resiliency and consequently is easier on both the rear axle and the chassis as a whole.

Some car makers prefer to "drive" by means of radius rods extending from the rear axle to



Timken Cam Brake.

the frame of the car. Several makers take the "torque" through torque rods fastened to a cross member of the frame near the transmission and extending to the rear-axle housing.

The torque rods prevent the housing from turning, as their action is the same as that involved when a boy holds a broom-handle at its ends and a strong man takes hold at its center and tries to turn it. The increased leverage due to the boy's hands being far apart enables him to overcome the greater strength of the man.

CHAPTER XVIII.

The Differential.

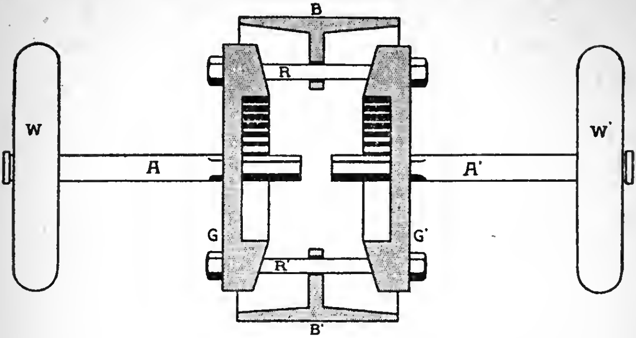
What It Is and What It Does—An Automatic Gear Which Compensates for Erratic Rear Wheel Movement.

THE differential comes into actual service in the center of a big bevel ring gear in the rear axle of a motor car. Here, as we have seen in our opening paragraph, it divides the power from the engine and transmits it to the rear wheels, so that one may revolve faster than the other when necessary. To illustrate the principle, the following brief description of the character and functions of a differential is inserted for the benefit of those readers who may be unfamiliar with this important part of the motor car.

The differential consists of a set of bevel gears located at the center of the rear axle. Its purpose is to divide the power transmitted from the engine equally between the two wheels, and to do this in such a way that one wheel may revolve faster than the other when necessary.

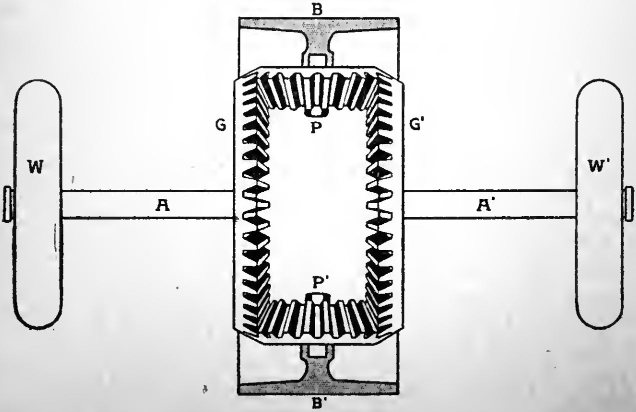
In a wagon the rear wheels are mounted on a dead axle and revolve independently of each other. There is, therefore, no need for a differential. In a power driven vehicle the rear wheels must still revolve independently and yet each must receive one-half of the power transmitted through the rear axle.

To illustrate the principle in as simple a manner as possible we show in Fig. 1 an experimental apparatus in which A—A' are the two live axle shafts to whose outer ends are fastened the wheels W—W'.



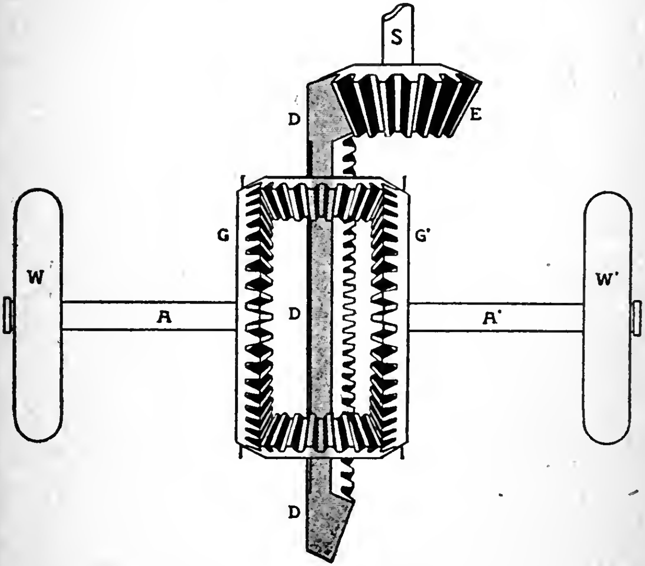
Mounted on the inner ends of the shafts A—A' are the bevel gears G—G'. Surrounding these gears and concentric with them is a belt-driven pully B.

It will be clear that if we connect the two gears solidly by the rods R—R', which in turn are securely fastened in the web of the pulley B, movement of pulley B will cause both the gears G—G' to revolve at the same speed in the same direction; and, since the wheels W—W' are, like



the gears G—G,' secured to the shafts A—A', the wheels will also revolve at the same speed in the same direction.

Now, to allow the wheels W—W', and, therefore, the gears G—G', to revolve at different speeds, we remove the rods R—R' binding the two gears together and substitute for these rods the pinions shown in Fig. 2. These pinions rotate



freely on the web of pulley B and their teeth are in mesh with the teeth of the bevel gears G—G'.

It is clear that when the pulley B revolves, its motion is transmitted through the pinions to the gears G—G' and on through the axles A—A' to the wheels W—W' just as it was transmitted in the apparatus shown in Fig. 1, but with this important difference—if wheel W is now prevented from revolving, the pinions will rotate on the web

and thus allow the gear G' to revolve, carrying with it axle A' and wheel W'.

If gear G revolves slowly, gear G' can revolve rapidly, or vice versa, because the difference in their motion is compensated for by the rotations of pinion P—P'.

It will also be clear that in all cases, the pressure transmitted from the pulley B through the pinions P—P' to the teeth of the gear G and the gear G' will be equal, because the distances between the centers of the pinions and the teeth of both gears are always equal.

In the simplest language possible, when gear G remains stationary, gear G' *and the pinions* roll around as it were, on gear G, the teeth of the pinions pressing forward on the teeth of gears G and G' with equal pressure.

Referring now to Fig. 3, we see the differential as actually used in the rear axle. In place of pulley B in Figs. 1 and 2, we have the driving gear D, and instead of two pinions there are now four, but the action is the same as that described in Fig. 2.

The driving gear D receives the power from a beveled gear known as the driving pinion, the latter being at the rear end of a "pinion shaft" coupled with the main propeller shaft which transmits the power from the engine.

CHAPTER XIX.

Care and Adjustment of Brakes.

Most Important Unit in Car From Safety Standpoint, Yet Brakes Receive Scant Attention—What to Do and How to Do It.

MOTOR car brakes are a vitally important detail and, strange as it may seem, there is no other unit or system that receives so little attention from the motorist. Various reasons are often advanced for the lack of attention given the brakes; however, the majority do not realize the importance of a properly adjusted brake system. When a motorist takes the responsibility of operating a car, he places himself and those who may be with him in a very unpleasant and sometimes death-defying position, unless he had absolute confidence in the brakes of his vehicle, which can only be gained from frequent inspection and adjustment. It is wrong to suppose that because the brakes worked properly on a previous application that the same degree of service will go on indefinitely. Neglected brakes usually fail to perform their work at the most critical times, and no doubt many motorists recall just such instances; perhaps the result was not serious, but might have been very disastrous.

It is not unusual to see a car on the streets in the congested traffic of the large cities collide with another vehicle, due to inefficient brakes. To arrest motion is equally, if not more important than to create motion, so it would seem that while considerable attention is being paid to maintaining good acceleration, the same attention should be paid to provide equally, if not better, retarding force. It is true that the brakes may not be up to the standard of other parts,

but this should not be an excuse for not maintaining them at their maximum efficiency. With some the brakes are a pet hobby, and occasionally one finds brakes which are harsh, due to improper adjustment. In this case the brakes create considerable resistance to the turning movement of the wheels.

It is not expected that every one should know the amount of strain in actual pounds that the

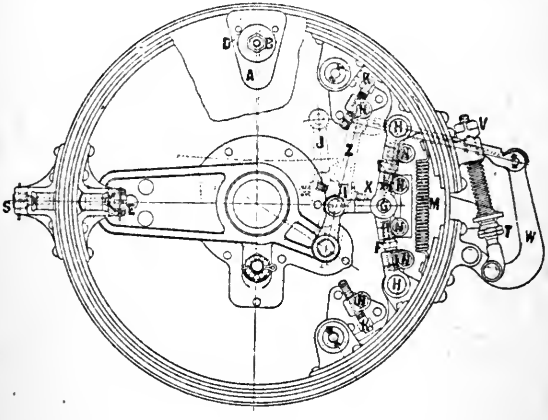


Fig. 1.

brake mechanism has to bear when one applies the brakes for stopping the car. That the amount is enormous is all the more reason why the brakes should be adjusted properly more than once or twice every year.

All the prominent types of brakes are illustrated herewith, and the various adjustments will be explained in terms which can readily be grasped by the lay mind. The illustrations cover both rear wheel and transmission brakes and apply to both hand and foot operated types.

The various types of brakes illustrated are not

necessarily used in the above combinations, as there is no reason why any of the many possible combinations should not be used. The arrangements here were made simply to show the various forms that are in general use. There are other types, but the principle of adjustment is practically the same and the following advice may be applied.

The brakes illustrated in Figures 1 to 9, inclusive, have some means of adjustment, and it will be noted that some types have a means for complete adjustment of the brake band or internal brake shoe, while there are also types which are not themselves adjustable and in which all the wear must be taken up by shortening the brake rods. Equalizers are generally being depended upon to absorb any unevenness of wear.

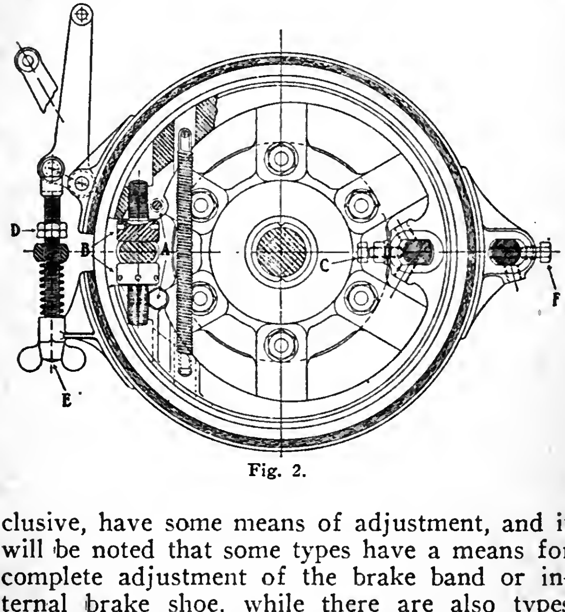


Fig. 2.

Figures 1, 2 and 3 illustrate types which are provided with a complete adjustment for both internal and external brakes; that is, adjustment

is provided for the points of control and the anchors. Figures 4, 5 and 6 illustrate types in which complete adjustment only is provided for the external brakes and no adjustment is provided for the internal brakes. Figure 7 depicts a set of brakes in which the conditions are just reversed, adjustment for both anchor and control being provided for the internal brakes only. The arrangement shown in Figure 8 does not provide adjustment for either internal or external brake. Figure 9 shows a transmission brake and its adjustment, while Figures 10 and 11 illustrate adjustments sometimes provided for in the control of cam operated internal brakes.

In making thorough adjustments a general inspection should be made of all parts of the entire brake system in order to determine that all parts are in serviceable condition. It is important that the brakes be evenly adjusted so that when either set is applied there is the same braking effect on both wheels. In order to accomplish this it will be necessary to disconnect the rods from the foot pedal and hand lever and allow the mechanism to release as far as possible. It is a good plan to oil or grease all connections at this time, since it will be possible to work the lubricant into the bearings and joints. Then jack up the rear wheels so as to be able to turn them and block the front wheels so the car cannot move.

In order to give a more comprehensive idea of the method of adjusting brakes, the writer will describe each type rather than a general description of all types. Referring to Figure 1, which represents one type of Timken brake used on several models of the Cadillac cars and various others, the method of adjusting the external brake is as follows:

Turn the anchor adjusting screw "S," until

that part of the band opposite the screw is brought as close as possible to the brake drum without touching it. Adjust the two nuts, "T," on the eye-bolt until the lower part of the brake lining just clears the drum. Next adjust nut "V" on the upper end of the eye-bolt to bring low "W" to the position shown in the illustration when the brake is applied.

When the brake is released, if the upper part

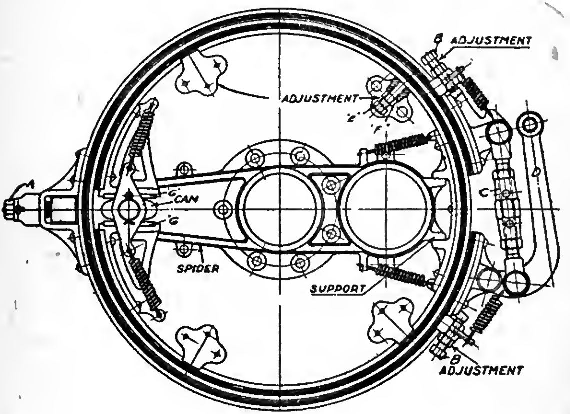


Fig. 3.

of the brake lining clears the drum more than 1/32 of an inch, the clearance should be reduced by the screw "X" in the rocker lever "Z." When the adjustment has been completed be sure to lock all adjusting nuts.

With the outer brake on one wheel completed, proceed to the other wheel, using the same methods there to adjust that brake. When this is done, connect the rod to the pedal again. In most cases it will be necessary to lengthen the rod, which can be done with the adjustable yoke end. It should be lengthened just enough so

that it will be necessary to pull with one hand on the rod to make the holes match.

With the rod connected one person should apply the brake while another turns the wheels, to determine whether both brakes are working evenly. Depress the pedal slightly and hold in this position until both wheels have been tested. Continue this operation until it is found that the brakes are in even adjustment or that a change is needed.

Such a change may be made by lengthening

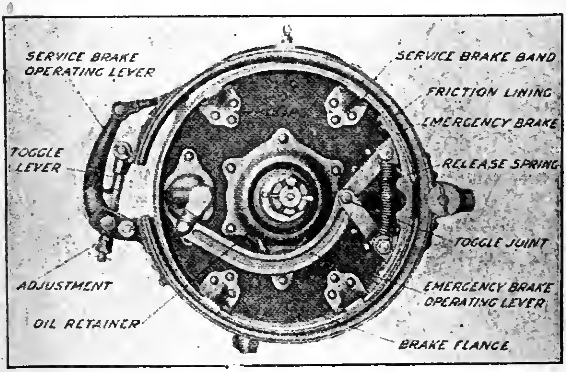


Fig. 4.

the rod leading to the brake, which is the tighter of the two. This will compensate for the uneven wear of the brakes which existed before the adjustment was made.

To adjust an internal brake is not near so easy as the external; but as this is so little used it does not require frequent adjustment, unless conditions are reversed and the internal is used for the service or foot brake. The brake illustrated in Figure 1 is so arranged that it can be adjusted without removing the wheel. Remove cover "A" from the opening in the brake drum by unscrew-

ing the lock nut "B" and turning the bolt to the left about one-quarter turn until the clamping bar "D" is released. Now turn the wheel until the opening gives access to the adjusting screw "E," and turn this screw until that part of the brake band lining in line with said screw is brought as close to the inner surface of the drum as possible without touching it. Then turn the wheel until it gives access to the six locking nuts "N" and loosen these screws. Turn adjusting screws "F" and "F," which have right-hand threads on one side and left hand threads on the

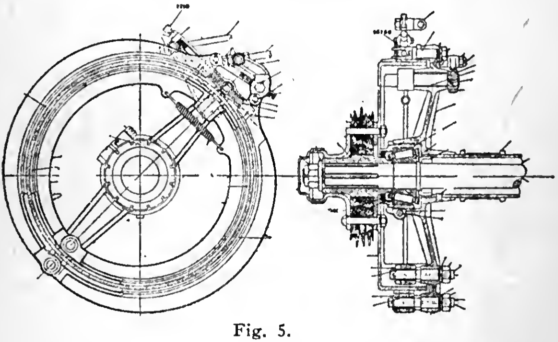


Fig. 5.

other, until the center of the pin "C" stands about three-quarters of an inch back of an imaginary center line drawn through the two pins "H" and "H" when the brake is applied. With the brake released adjust screw "I" in the lever "J" and the stop screws "K"-"K" until the lower and upper parts of the brake lining clear the drum 1/32 of an inch. After making the adjustments, be sure to lock each one of the locking screws "N." Also replace and fasten securely the cover of the opening in the drum.

The method of testing and adjusting rods is the same as for the foot brakes.

In some constructions it is necessary to remove the rear wheel, and the proper adjustment can usually be obtained by using as a guide the outer edge of the circular plate that forms a guard for the protection of the brake. However, it is much better to use a little more time by replacing the wheel and trying the brakes for both clearance and holding power. It may be necessary to do this two or three times.

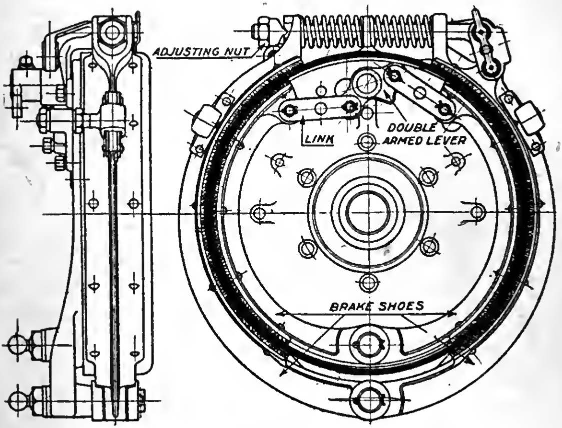


Fig. 6.

The brake assembly shown in Figure 2 has an external brake similar to the one shown in Figure 1, and may be adjusted as follows: The jam nuts "D" should be lowered so that the top of the brake band will have at least 1/64 of an inch clearance, and the wing nut "E" is adjusted until the proper clearance is obtained on the lower part of the band. The adjusting screw "F" in the anchor is used to hold the band 1/64 of an inch away from the drum and should be so adjusted. The internal brake is of a type used by several car makers and also on some

Timken rear axles. To adjust this it is necessary to remove the rear wheel, which should be done by following the instruction given in the instruction book. Loosen binder screws "A" and adjust each half separately by cam plates "B," which have right-hand threads, a few turns, and replace binder screws "A." The adjusting screw "C" is used to provide the proper clearance at the anchor of the brake. Some makers advise using a dummy or skeleton drum, that is, one with the outer flat surface cut away, to give ready access to the interior. Garage men who have enough of such work to warrant it, usually have, or can obtain one, as it is a great time saver.

Figure 3 illustrates a set of brakes designed for heavy trucks, representing the practice of the Clark Equipment Company, builders of internal gear-drive axles, used by several truck builders. The outer brake has the adjusting screw "A" at the anchor for adjusting the clearance at this point of the drum. The upper and lower portions of the band at the opposite ends are adjusted by the screws "B," which are retained in stops attached to the brake spider and securely locked by nuts. These should be loosened and the screws "B" adjusted until the proper clearance is obtained. The two ends of the brake are connected by clevis rods and a turn buckle "C," which permits adjusting the position of the brake lever "D," and this in some cases will eliminate rod adjustments.

It is necesary to remove the wheel in order to adjust the inner brake, which does not have an anchor adjustment, but instead is provided with four supports equally spaced around its inner circumference and provided with adjusting screws "E," locked by nuts "F." These four nuts must be released and the screws adjusted

until the proper clearance is provided at the four points around the inner circumference of the drum. The internal brake is also provided with hardened steel cam plates, "G," which can be replaced when worn.

The brakes shown in Figure 4 are used on the Buick and all other vehicles equipped with Weston-Mott axles. The usual adjustment outlined above is used on the toggle lever of the external brake, while a spring is relied on to provide proper clearance at the anchor. As previously mentioned, this adjustment brings the ends of the lining close to the proper point of clearance on the drum.

The internal brakes are of the non-adjustable type and compensation for wear can only be made through the brake operating rod. The method of procedure will be explained later.

The brake used on the Pierce-Arrow, six-cylinder cars are shown in Figure 5. The internal brake being of the non-adjustable type, and these are used for the foot brake instead of the outside, as in the conventional arrangement. These are of the steel shoe type with bronze linings. Adjustment is possible only through the brake rods.

The external brakes are used for emergency purposes and are also of the steel shoe type with bronze linings; however, an adjustment is provided. These shoes are hinged at one end, which forms the anchor, and these ends may be drawn together by means of the toggle arrangement shown. The toggle joint of the brake is made adjustable, while the two ends of the brake may also be drawn together for proper clearance by a turn buckle and set screw.

Another type of hinged shoe brake lined with friction fabric is shown in Figure 6; the internal brake being non-adjustable, while the external

brake is provided with an adjustment on the toggle turn. The method of adjustment has been explained above.

Figure 7 depicts another Timken construction used on some vehicles. The external brake is of the semi-adjustable type, since the customary adjusting arrangement is made in the toggle connecting the upper and lower ends, and a spring is used to provide proper clearance at the anchor. The internal brake has a wedge expanding mech-

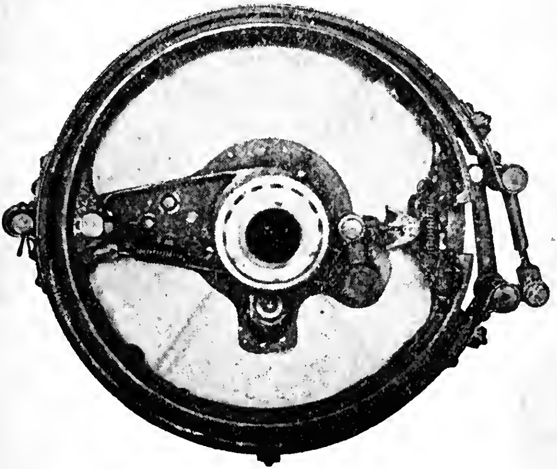


Fig. 7.

anism acting against rollers in the ends of the brake band. The usual set screw arrangement for adjusting the clearance at the anchor is provided, while the ends of the band can be adjusted by removing the brake spring and the band expanded so that the wedge can be adjusted in or out to provide proper band clearance at this point.

As previously mentioned, the brakes shown in Figure 8 are of the non-adjustable type, and all

adjustment for wear must be taken up in the operating rods. Brakes of this type are usually found on popular priced cars of light weight, and consequently the amount of work performed by the brakes is comparatively small. In this case the usual procedure of jacking up the wheels is followed and the pedal and hand lever are released as far as possible and a trial made by applying the brakes in order to approximately ascertain how much the rods must be shortened. In some cases the rod leading to the foot pedal and brake lever can be shortened sufficiently to take up the wear, while in others it may be neces-

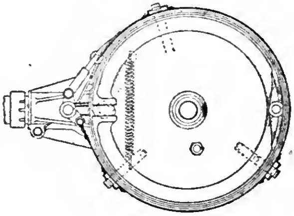


Fig. 8.

sary to shorten the rods leading to the rear axle. The brake rods should always have a slight tension, as mentioned above. In some cases wing nuts are provided either at the foot pedal, hand lever or the equalizers which can be drawn up to shorten the rods and the labor of disconnecting these eliminated.

The usual type of transmision brake is shown in Figure 9, which may either be connected with pedal and used as a service brake, as shown, or connected with the hand lever and used as an emergency brake. A single adjustment is usually provided, which serves as a complete take-up for wear and consists of a knurled screw, "A," connected with the toggle lever, which can be drawn up to provide the proper clearance at

the ends of the band similar to the method described in connection with rear wheel brakes. This adjustment, like the ones for the external brakes in Figures 1, 2 and 6, is locked by a V-shaped tongue fitting in a groove, held in contact by a coiled wire spring.

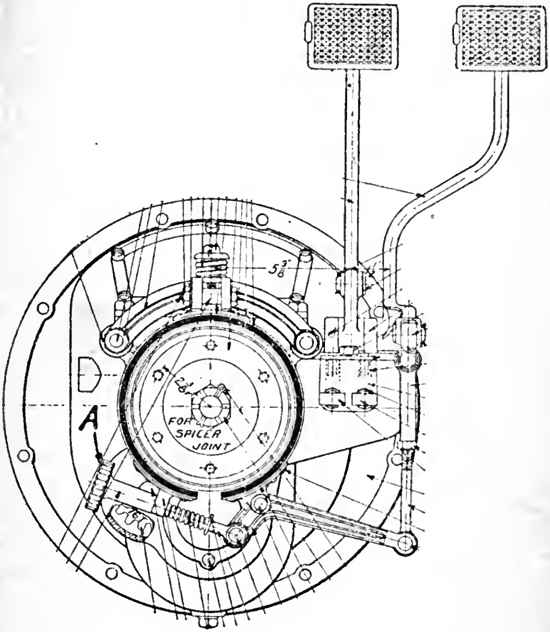


Fig. 9.

In some cases the brake levers on the wheels are provided with adjusting sectors which provide a greater range of adjustment that the brake rods. Two such sectors are shown in Figures 10 and 11. Figure 10 being a construction used on a prominent make of internal gear drive axle for motor trucks, and consists of a sector keyed to the brakeshaft and provided with a number

of holes. The brake lever is free on the shaft and connected to the sector by a bolt and nut. In this construction the adjustment is made by removing the bolt and bringing the cam to proper position for band clearance and then attaching the lever by inserting the bolt through the holes which communicate. The construction shown in Figure 11 is used on the Overland and several other cars and differs from the above in that a slot is provided in the sector and the connection made by the teeth on it and the lever and held in engagement by a bolt.

The Care of Brakes.

In addition to adjustment, brakes require attention on the part of the operator. Here the question of lubrication arises again, for, no matter how perfect the adjustment, they cannot be evenly applied unless all joints in the linkage are free. A drop of oil on the various joints of rod and lever and in the bearings will prevent rusting and squeaking.

Most all brake bands are lined with a special lining, and occasionally this will fail to function properly, due to oil, grease and soft mud, and in this condition they are less effective than when in proper condition, hence more care should be exercised when driving under such conditions. If oil, grease or mud collects on the friction surfaces, it may be removed with gasoline, after which the parts should be wiped dry. Should such a condition exist on tours it can be remedied by introducing a little Fuller's earth carefully between the band and the drums. This will absorb the oil or grease and make the bands hold. Brakes should never be permitted to drag or bind, as this causes them to wear rapidly and also places an additional resistance on the en-

gine. A gripping brake can be eased by applying a little oil and graphite mixed.

When brakes fail to hold it does not necessarily mean that they need adjustment. Before jumping at the conclusion that they require adjustment or relining, the car should be jacked up and the frictional surfaces and bearings carefully examined. Failure of the brakes to hold may be due to the insufficient travel of the rods connecting the brakes with the foot pedal or hand lever. In jacking up the car, care should always be taken to put the jack under a substan-

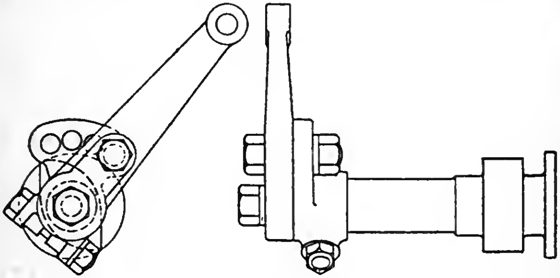


Fig. 10.

tial part of the axle, never against a truss-rod. If it is necessary to remove the wheels to inspect the brakes, be sure to properly adjust the wheel bearings when replacing the wheel.

Relining Brakes.

Due to long service the brake lining will lose its usefulness, and it then becomes necessary to reline the bands with a new fabric, or metal shoe if they are metal to metal. This is quite a difficult problem for the average layman, and the majority of motorists usually place this work in the hands of a repairman; however, the method of applying these linings will no doubt interest our readers, for some enjoy doing their own

work which they feel can be undertaken without too great a risk.

The first step is to obtain the correct measurement of the lining for thickness, width and length. The width of the lining should correspond with the width of the internal and external bands, while the length can be obtained with a tapeline around the external brake band, allowing approximately one-half inch overlap at the band opening. The internal brake will work out about an inch shorter. Two lengths of each are required for each set of brakes. After the car has been jacked up from the ground and before removing the wheels, it is by far the safest to place the axle on good, strong horses. However, if these are not available, block the front wheels in both directions with wood blocks and nail these to the floor, if possible, with small wood strips. In removing the rear wheels always consult the instruction book and follow instructions carefully. When the wheels have been removed, the band can easily be disassembled by removing cotter pins, clevis pins, etc., adjusting screws and springs at both ends. In doing this, be careful to observe how the various parts are assembled. A good plan to follow is to use small boxes for the parts of each brake individually. While doing this also clean all parts and the grease which may have accumulated on the axle and brake drum.

The most tedious part of the entire job is the removal and replacement of the lining. A simple method to remove the rivets is to clamp the band in a bench vise, and chipping off the heads of the rivets, they can then be driven out with a small punch. If the old lining is in such condition that it can be used as a template, the length and location of the holes can be obtained from it. However, as a general rule this is not the

case and some other method must be followed. Perhaps the safest one is to use the brake drum on the wheel as a fixture. Place the band around the drum and insert the lining between these, allowing the end of the lining to overlap one end of the band about a quarter of an inch. Now clamp the ends of the band together so that the effect of the on position is obtained. If a clamp is not available, wire or good heavy cord can be used. Be careful to work the lining snugly

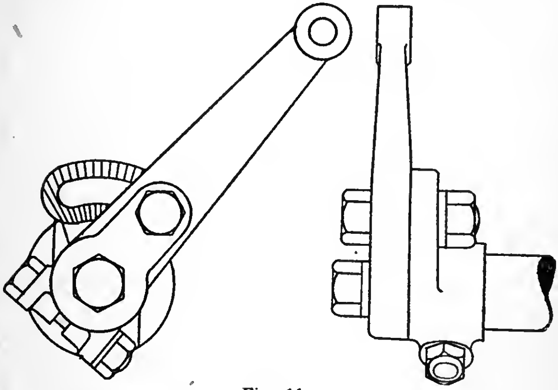


Fig. 11.

around the drum and then cut it off one-quarter inch larger so that an overlap of one-quarter inch on each side is obtained. In this position the holes can be marked with a short pointed instrument, pencil or soapstone. Release the band and punch the holes with a belt or harness punch. After the holes have been punched the lining can be attached to the band with a few small bolts at intervals around its inner circumference and the holes countersunk slightly for the heads of the rivets. This must be done so that the heads will set slightly below the surfaces of the lining.

The countersinking can be done with a wood countersinking tool and a hand brace. Be sure to have the tool sharp so that it will not tear the lining.

In order to make a neat job of riveting it is almost necessary to have a vise, unless there are two people, one holding the work while the other is doing the riveting. An old belt can be

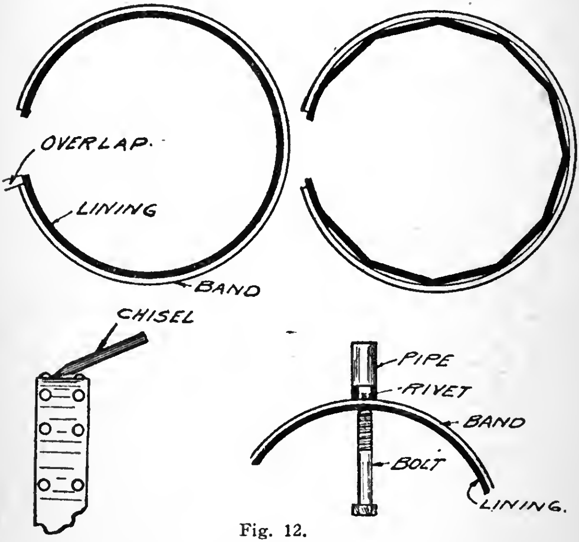


Fig. 12.

used to rest the rivet head on so that it can be seated properly in the lining and also as a rest for riveting. The rivet should be drawn snug with a rivet set; however, if this is not available, a piece of pipe can be used. Now set the rivet head with three or four blows of the hammer; do not attempt to draw the rivet too much, as it will tend to draw through the fabric. The rivet should not extend more than 3/16 of an inch beyond the band for forming the head. A

light, sharp blow with the hammer is much better than a heavy one, as it will spend its force at the desired point. In riveting, be sure to have the lining fit the band snugly at all points, and do not remove the temporary holding bolts until necessary. The inner band is treated in the same manner; however, this is much simpler, as the material is being drawn over an outside surface instead of the inside of the band. Perhaps the only difference lies in marking the holes for internal lining. This may be done by first allowing the proper overlap at the end and marking the first two holes; punch these and insert the temporary bolts. Then stretch the lining around the band and mark the holes. If shoes are used instead of a complete band, it will be necessary to follow this method for each shoe. Figure 12 illustrates the various features mentioned above.

In reassembling the brakes, be careful to place every part in its proper position, and it will be necessary to make a complete readjustment as outlined above. In replacing the wheels, be sure to follow the instructions given in the instruction book which is supplied with each machine. If you have misplaced this, a copy can be secured gratis from the maker of your car.

CHAPTER XX.

Lubrication Pointers That Have Merit.

Application of Oil Should not Cease When Motor Has Been Properly Lubricated—Entire Car Should Be Gone Over Systematically—A Worth While System to Follow.

IT is the driver who runs his car just as long as it will hold together before making adjustments that is usually the one most dissatisfied with it. The automobile is not different from any other piece of machinery, except that it must work under a greater disadvantage. Adjustments must be made from time to time if the machine is to last any appreciable period. A loose bearing may be tightened as soon as observed and no harm done, but if the car is continually driven with that bearing pounding itself out, a new bearing is the only remedy.

Noise is a positive indication of wear and tear. Noise is the outward sign that parts are being worn away and that expenses are piling up. It is a matter of economy to make all adjustments promptly. At the same time tinkering with any of the adjustments should not be tolerated. Noises are difficult to locate at times, but no attempt to change a single adjustment should be made until the trouble is positively located. Tinkering wears out as many cars as does the normal driving.

The proper lubrication of the entire motor car is, perhaps, the best insurance of freedom from trouble. Lubrication charts are furnished with the car, but it is far better to learn the amount and frequency of lubrication required by actual observation than it is to rely entirely upon such a chart. Weather and road conditions and the

method of driving the car have as great an influence as the actual mileage traveled. Heavy roads mean more power with greater bearing pressures, and consequently more oil.

It is a good policy to go over the entire car at least once or twice during the year and clean out all oil cups and supply reservoirs. After an oil has been used for a considerable length of time in the motor it becomes black and thin and sediment collects in the base. The greater percentage of the lubricating qualities have been lost. Drain the crank case oil reservoir, and flush it out with kerosene. See that the oil line screens are not clogged up with the heavy residue that often collects. Fill the reservoir with a fresh supply of oil. It is wonderful how an entire new supply of oil refreshes a motor. It is economy in the end measured in dollars and cents. The transmission and differential gears must transmit all of the power from the motor. The grease for these parts must be heavy enough to cushion the teeth, but light enough to prevent the loss of power that would be required for stirring up a heavy viscous grease.

Lubrication of the universal joints is as essential as is that of the motor. The universal joint is for the purpose of transmitting power around the corner of the drive shaft as the shaft bends with each vibration. The universal joint parts must be fitted closely if they transmit the power smoothly. Unless a film of oil is maintained between these closely fitting parts undue friction, and hence wearing of the parts must arise with loss of power at the rear wheels, or lost motion accompanied by creaks and groans. Flush out the universal joint housings and use a new supply of clean grease.

Flake graphite can be used to very good advantage in all greases, even in the motor, providing

that the splash system of lubrication is employed. Flake graphite is in itself a good lubricant. When used mixed with oils it forms a perfect coating on the bearing surfaces so that all wear comes between the two coats of graphite instead of between the metallic surfaces. A teaspoonful of graphite to each gallon of oil is ample.

Neglect is one of the prime factors in the numerous kicks which automobile men are constantly confronted with.

If an automobile owner will map out a simple, regular system for oiling and greasing his car his satisfaction will reach the maximum and his troubles the minimum. His car will be 99 per cent efficient and his worries decreased to a considerable extent.

The front spring bolts and shackles should be well greased once to every 300 or 400 miles of travel. Neglect of these parts will soon produce noise. The same attention should be given to the rear spring joints. The rear axle gear-set and transmission gears should be inspected and lubricated at least once to each 2,000 miles of travel. In this connection attention should be paid to the proper selection of materials.

The clutch shifting parts and brake joints should be kept well oiled at all times. In oiling the magneto or other ignition devices one should bear in mind the functions which these parts perform.

Too liberal a use of oil at these points will often cause trouble and in some cases put the ignition out of commission. Two or three drops of oil once in every 2,000 miles will be sufficient. This rule may also be applied to the care of the starter.

Motors having water pumps should be given attention at this point. The grease cups should be kept filled with hard grease and given a turn

every day or two providing the car is in constant use. In oiling the motor itself great care should be exercised in using oils of the proper weight. It is a very good idea to keep a close tab on the oil gauge and the oil feeders. Oftentimes the feeders become clogged, or they may run too freely. This is a waste on the one hand and a serious neglect on the other.

All moving joints exposed to the dust and dirt should receive constant care as to oiling. Dry spring leaves can be lubricated by separating the leaves and allowing a mixture of graphite and oil to run between them.

Wheel bearings should be packed with hard oil at least once in every 3,000 miles. Much care should be used in greasing the steering gear and all connecting parts. A fairly soft grease should be used on the steering knuckles, as any binding here will make steering difficult.

CHAPTER XXI.

Keeping Up Appearance of the Car.

Some Sidelights on the Proper Treatment to Keep the Finish, Upholstery and Top in Presentable Shape—What Not to do When Washing the Car.

WHENEVER the car is to stand for some time, it is well to jack up the car and allow the axle to rest on supports. Removing the weight from the tires does not decrease the air pressure to any degree measurable by the ordinary tire pressure gauge. The damage is done to the tires by allowing them to remain in one position with the flat spot of contact until the tire takes a permanent set.

The fabric is creased and the rubber is stretched permanently, so that a weak spot is developed. Keep the tire rims free from rust by sand-papering and painting with graphite.

No machine can remain in permanent adjustment with constant running when it has a coating of mud and sand dried and baked onto it. Yet many automobile owners continue to drive their cars day after day with no thought of removing the dust and mud that accumulates with each drive. The tiny particles of grit work into the smallest joints about the moving parts and produce their cutting effects like so much powdered emery. The result is slow but inevitable. Bearings are ground out, knocks develop, and the car is ready for the repair man.

Never wash the car in the bright sunlight. The water dries rapidly and streaks are left. The man who does not have water available under pressure often uses such a condition as an excuse

for allowing the car to become encrusted with mud. As a matter of fact, it is best that a hose never be used on the finish of a car. The pail and sponge used intelligently produce the best results.

The cleaning of the car should become a regular and systematic duty. Use two pails and two sponges. One pail and one sponge should be preserved for the final rinsing of the varnished parts. Start on the top and work down. Never use gasoline or kerosene in cleaning the top.

Most top materials contain rubber. Castile soap and water will remove the grease spots. Fill the sponge full of water and dash the water on the body gently, so that the dirt particles may flow off without leaving scratches. Never attempt to rub the dirt off. The sooner the car is washed after being on the road the easier will be the process of cleaning and the longer will be the life of the finish. Should the car be new, frequent applications of clear water will tend to harden the varnish and preserve the lustre. The varnish may be damaged, however, should the cold water be used on the car when the surrounding temperature is near freezing.

Keep the motor clean by all means. Kerosene applied with a brush is very effective in removing accumulations of grease and dirt. Use a mixture of common washing soda and water to wash out the radiator and cylinder jackets at least once or twice during the year, to loosen up all scale and sediment. Do not let this solution get on any painted surface. Thoroughly rinse the cooling system with clear water after this process. Keep the outside of the radiator clean and see that the air passages at the bottom do not become clogged with mud.

It is the little care given regularly that counts and keeps the car running smoothly. A few

minutes attention each day will save many hours later. There is no machine built that stands up under the continued abuse that the ordinary automobile receives.

CHAPTER XXII.

Hints on Maintenance and Repairing.

Suggestions for Removing and Replacing Anti-Friction Bearings of the Ball Type—Tools for Facilitating the Work — Bearing Regrinding as a Means to Economy.

MANY anti-friction bearings are damaged in the removal or during application when repairing mechanism in which they are mounted, but this results more from ignorance of their nature than deliberate intent to damage them. A common cause of bearing failure is noted when they are driven in place by blows from an ordinary machinist's hammer applied directly to the bearing face or through the medium of a steel drift or blunt cold chisel. Ball-bearings should never be driven in place or removed by the use of steel or other hard metal tools, because the race members may be permanently sprung or deformed by this treatment.

Whenever the construction permits, bearings should be removed by direct application of pressure to the part that is tightly fitted. When a bearing is mounted in a wheel hub, as indicated at Fig. 2, a simple form of wheel puller can be employed to advantage. This is a substantial casting of malleable iron or bronze made approximately the same shape as the hub cap, threaded inside to fit the hub and having a substantial set screw at least .75 inch in diameter passing through the threaded boss at the centre. The screw should be long enough to pull the wheel and bearing entirely off the spindle or axle tube. A shouldered plug of steel with a depression drilled therein to locate the screw point may be

pushed in the hollow tube to centralize the screw pressure. In use, the wheel puller casting or wheel is kept from turning and, as the screw advances, it pulls off the wheel and the bearing it contains.

A modified form of puller having two arms and a cross-beam that can be used when a bearing cone must be removed from an axle or spindle is outlined in Fig. 1. An attachment to permit it to remove a bearing of the unit type, such as a single or double row annular, without exerting any pressure on the balls or outer race is clearly

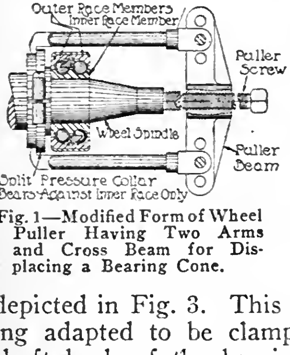


Fig. 1—Modified Form of Wheel Puller Having Two Arms and Cross Beam for Displacing a Bearing Cone.

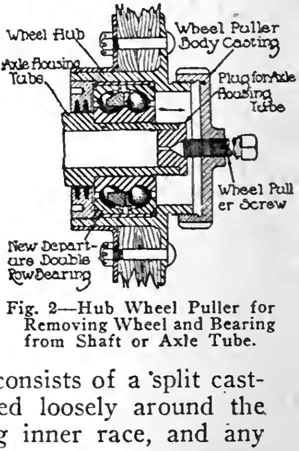


Fig. 2—Hub Wheel Puller for Removing Wheel and Bearing from Shaft or Axle Tube.

depicted in Fig. 3. This consists of a split casting adapted to be clamped loosely around the shaft back of the bearing inner race, and any pressure exerted to remove the bearing is applied directly against the member which is a force fit on the shaft. When any form of hub or bearing puller fails to start the member to which it is applied by direct pull, its action may be accelerated after the screw has been tightened sufficiently to place the parts under a certain initial tension by a few sharp, well-directed hammer blows on the beam or main body of the device.

In all cases where possible the pressure applied

to remove a bearing or part should be exerted directly against the portion that is a tight fit on the shaft or in the housing. In most cases it is the inner member of the bearing that is a force or press fit on the shaft; the outer race member is usually a push fit in the housing and may be easily removed. If it is necessary to force the bearing off with a series of blows, always use a brass or hard babbitt metal bar or drift between the bearing and hammer, or even a piece of hard maple, hemlock or oak. Do not direct all the blows at any one point on the bearing, as this

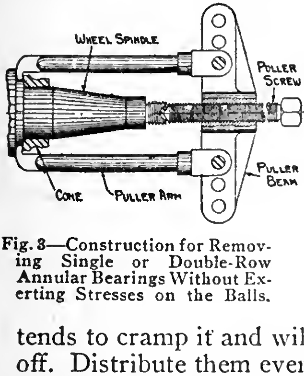


Fig. 3—Construction for Removing Single or Double-Row Annular Bearings Without Exerting Stresses on the Balls.

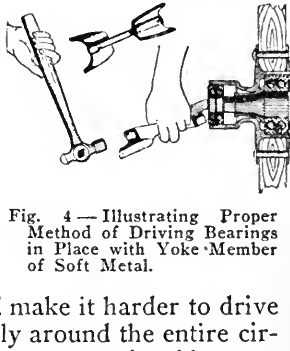


Fig. 4 — Illustrating Proper Method of Driving Bearings in Place with Yoke Member of Soft Metal.

tends to cramp it and will make it harder to drive off. Distribute them evenly around the entire circumference, always having successive blows at points diametrically opposite. When driving bearings in place it is always best to use some form of soft metal yoke member, as shown in Fig. 4, or tubular section piece as shown in Fig. 5. With either the yoke or the other, tubular form, the hammer blows are distributed evenly, and the bearing is driven in place without injury to either shaft or bearing components. When a double fork member is used one end can be made to drive against the inner race member while the other can be spread enough to fit the outer race if desired.

Ball-bearings do not require the continual application of lubricants that is called for by plain bushings, and, to a lesser degree, by roller bearings, but this does not mean that lubrication can be neglected or done carelessly.

The important point to observe is that none but pure mineral oils or grease be used, as any that show traces of acid or alkali, or that may become rancid from oxidization, will cause etching and roughing of the highly finished surfaces of the balls and races.

It has been the custom of motorists in the years past to discard ball bearings when they have became worn. The supposition prevailed that worn-out bearings and bearing housings were merely "metal," and it is only in the past few years that the motor world has become acquainted with the fact that worn bearings are not useless and can be restored. When it is understood that a reground bearing is absolutely as good as a new and that the rejuvenation is accomplished at one-fifth the expense of what new ones cost, it will be appreciated that a real economy has been wished upon the motor world.

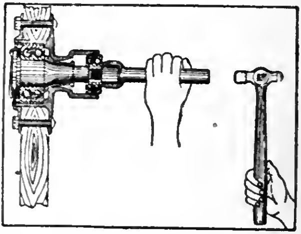


Fig. 5 — Showing How the Blows of Hammer May Be Distributed Evenly with Tubular Tool.

Lubricants best adapted range from light machinery oils used in small high-speed bearings, such as fitted in magnetos, lighting generators or starting motors, to the viscous grease utilized in those subjected to heavy loads and revolving at low speeds, as wheel or differential bearings. Whenever the bearing can be immersed in a bath of oil and properly protected from water and

grit a lighter oil can be used, but when bearings are housed where dirt or water may get in, then the use of ample quantities of viscous lubricant, such as vaseline or other mineral grease that is free from acid, prevents the foreign matter working in between the balls and races.

Regrinding a bearing entails very careful and precise work. In fact, so accurate does it have to be that the outside diameter will not have been changed to the extent of one-thousandth of an inch.

In putting a bearing in "as good as new" condition, every reliable grinder must regrind the raceways so that the proper fitting can be made and the bearing allowed to perform its duties without a "hitch," which often is the case when not properly ground. New balls must be inserted and new retainers used where necessary. If all these things are properly and correctly done, the bearing should be returned to the owner not only as good as new, but should perform all the duties, and at the same time give to the owner of the machinery, or, rather, automobile, as much service as a new bearing.

CHAPTER XXIII.

Carbon, its Source and Elimination.

Poor Oil the Chief Cause of Carbon Deposit—How It Affects the Motor Running and Increases Wear—Various Methods of Effecting Carbon Removal.

WHEN a sample of fresh oil is entirely boiled away, it leaves a black layer of carbon on the interior of the vessel in which the boiling takes place. This deposit is called residual carbon.

Mineral lubricating oils *are hydro-carbons;* that is, they consist of a chemical combination, in various quantities, of the element *carbon* and the element *hydrogen.* It is evident, therefore, that there can be no such thing as a "non-carbon" oil.

All oils when boiled or distilled to the end will leave a carbon residue, the quantity varying from a trace with highly filtered oils to a veritable incrustation with inferior oils. No oil exists from which carbon will not be produced when it is exposed to high temperatures. The amount of this carbon deposit depends largely upon the grade of the crude petroleum from which the lubricating oil is made, and the care and thoroughness exercised in the process of refining.

For the proper lubrication of piston, piston rings and cylinder walls, a film of oil must at all times cover their contact surfaces. Unfortunately, the piston, driven forward by the exploding gases, exposes the protecting film of oil on the cylinder walls directly to the intense heat of the explosion (between 2000° and 3000°

Fahr.) This temperature is far above the flash point of any known oil. As a consequence, part of the oil film is flashed off and escapes with the exhaust gases. On the up-stroke of the piston a small portion of the partly burned oil film is carried into the combustion chamber, where it spreads over the walls and is further consumed by the heat of succeeding explosions. A continuous feed of oil to the cylinder walls renews the depleted protective film. From a consideration of these facts, therefore, it is obvious that the operating condition existing in the explosion chamber and upon the cylinder walls of an internal combustion motor, is one of uninterrupted distillation to the end, and the carbon deposit left behind is residual carbon.

CARBONIZATION.—Rapid carbonization of a motor invariably results from the use of a poorly refined oil of inferior quality. Hot carbon and the sulphur compounds freed by the combustion of poor oil passing between valves and valve seats, erode and pit both, necessitating frequent regrinding. The carbonization of the explosion chamber, valves and top of piston is also caused by the use of an oil of incorrect body, too light or too heavy, too high an oil level in crankcase, or by the presence of mechanical defects in the motor.

Figure 1 illustrates one of the most serious of mechanical defects contributing to the immediate carbonization of any motor in which it exists, namely, piston ring leakage. The effect of this leakage is the destruction of the oil seal between piston and cylinder with attendant loss of compression and power. A surplus of oil is drawn into the cylinder during each inlet stroke, and the highly heated gases escape past piston rings and piston into the crankcase during each expansion stroke. This breaks or "splits" the oil there and

destroys its lubricating properties within a short time.

Since carbon on the walls of the combustion chamber takes up an appreciable amount of space and proportionately decreases its volume, the compression pressure increases to a dangerous point, where premature or spontaneous ignition occurs. The low heat conductivity of carbon, evidenced by incandescent points (Fig. 2), only

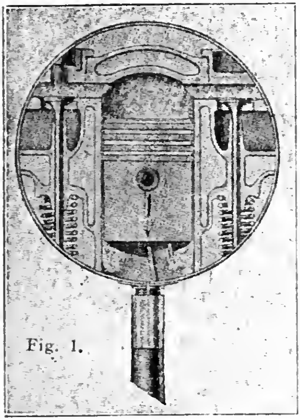


Fig. 1.

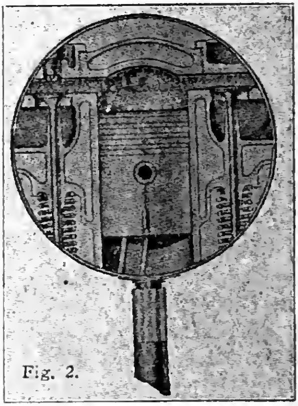


Fig. 2.

aggravates this situation. These glowing points ignite the explosive charge before the piston reaches top dead center, thus giving rise to terrific blows upon the bearings, and to unnecessary wear. *All noise and knocks mean loss of power.*

A troublesome carbon deposit and heavy exhaust smoke usually attend the use of too light an oil in the majority of motors. The consumption of a light oil is much greater than that of other grades, and for this reason a larger quantity is fed. Due to its light body, such an oil is copiously sucked past piston rings into the ex-

plosion chamber. Compression losses result because of the poor gas seal afforded by light oil. If an attempt is then made to decrease carbonization and smoke by cutting down the oil feed, insufficient lubrication of the upper portion of cylinder walls and destructive scoring end the story. (See Fig. 3.)

Buying a cheap grade of oil because of the low price is not true economy, but will eventually prove to be a very expensive practice. The principal lubricating mediums commonly used are fluid oil and semi-fluid oils and greases derived from both mineral and animal sources. Graphite, one of the most important lubricants known, is a form of crystalline carbon. The mediums best adapted differ with the nature of the work the parts are to perform. An oil that is suitable for one portion of the automobile mechanism may prove actually injurious to other parts.

By adding about one teaspoonful of ground flake graphite to every gallon of cylinder oil, it is possible to carry to all surfaces a material that is finer than the most minute pores of the metal and which will gradually cover the metal with a film which heat cannot easily destroy. The benefits derived from the use of graphite in oil are accumulative, for which continued use all the bearings, cylinder walls and piston rings are protected by a lubricant which impregnates the metal. All graphite is not lubricating graphite, however, nor is all lubricating graphite suitable for use in cylinder oil. Care must be exercised and only finely ground flake graphite of the best quality should be used.

Cylinder oil should be derived from a crude petroleum base, because oils of this nature are inorganic and are not liable to decompose by exposure to the air or by heat as are the organic

lubricants derived from animal fats or vegetable sources.

The best cylinder oils are obtained in three grades: light, which has a consistency slightly greater than machine oil; medium, which is somewhat heavier than the light, and is an intermediate grade between that and the heavy-bodied oil which has the consistency of warm molasses. The medium grade is best suited for use in summer, and the light grade in winter.

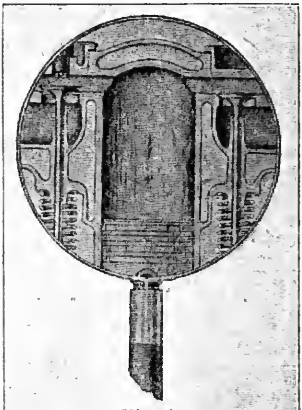


Fig. 3.

The removal from time to time of carbon deposits which accumulate in the combustion chamber and on the tops of the pistons is necessary on all gasoline engines. This carbon deposit is always a source of difficulty to an owner or driver and its presence tells so adversely upon the running of the engine. The frequency of the carbon removing operation depends entirely upon the severity of the service and the quality and quantity of the lubricating oil. This carbon is a residue product of oils and its presence is indicated

by a tendency to knock when climbing a hill, unless the spark is unduly retarded, and also by the overheating of the engine.

This carbon is a deposit of heat decomposition of the fuel or lubricant, or both, under pressure and in the presence of too little air for combustion. Too rich a mixture almost invariably results in the formation of carbon, which also follows upon the use of oils that do not stand high enough temperatures, or that are otherwise of poor quality. It may also be caused by delaying the opening of either intake or exhaust valve, so that not enough time is provided for the opening of the exhaust.

When this carbon is present in lumps, it will tend to become red-hot and cause pre-ignition. Small particles may lodge on the valve seats, preventing them from closing, as well as lodging in the piston rings, so that compression and consequently power is lost.

There are several ways of removing carbon, which depend upon the facilities at hand. It may be removed with denatured alcohol, scraping or by burning it out with oxygen.

Denatured alcohol has also been found to be a good decarbonizer. It should be introduced into the cylinders while hot and allowed to remain there over night. It will then loosen the scale on the cylinder walls and pass out through the exhaust.

In using decarbonizers on a four or six cylinder motor, two cylinders must be treated at a time, as it is best to bring the pistons in the cylinders into which the decarbonizer is introduced into the topmost position with all valves closed.

When denatured alcohol is used an ounce or so shall be used for each cylinder and should be squirted up against the top of the inside of

the cylinder head through a spark plug hole with a long curved spout oil can. Also put a little in spark plug and screw it in place again.

The necessity for scraping may be minimized by injecting a tablespoonful or two of kerosene into the cylinders after the day's run while the engine is still hot. Kerosene when used in this way has a solvent action, which may be utilized more fully by turning the motor over a few revolutions, with the ignition off, so that the kerosene will work over the entire cylinder surface.

When it becomes necessary to scrape the cylinders, intake valve and exhaust valve port plugs should be removed and the engine turned over until the piston reaches its top center. The carbon deposits can then be removed by carbon scrapers. These are sharp tools of different shapes, bent so as to reach the piston head and top of the cylinder. All carbon removed should be scraped toward the exhaust valve, and when the scraping is completed the motor should be turned over until the exhaust valve has opened. Then scrape the carbon past the valve into the exhaust passage, whence it will be blown out. Now brush the surfaces clean and be sure that no carbon remains between the valve and its seat. Finally, wash with kerosene. A small electric light can generally be placed in one valve port plug hole and the condition of the surface noted through the other one.

In order to remove carbon from the walls of the piston and rings, it becomes necessary to dismantle the motor. Either operation is a long and tiresome job at best, but the improvement in the power and running of an engine afterward will more than compensate for the work expended by the owner.

Oxygen can also be used for removing carbon by burning it out; however, this method is mostly

used by large repair shops and may harm the engine if the work is not properly understood. The object of this process is to burn the carbon out so that flames will not be directed to any particular spot any length of time.

A good plan to follow when scraping carbon is to grind the valves after it has been removed, but do not disturb them until the scraping has been completed.

CHAPTER XXIV.

Little Things That Count in Car Care.

A. Compilation of Useful Information, Short Cuts and Kinks That Will Prove Helpful to the Motorist—Simple Ways of Accomplishing Complex Operations.

Cleaning the Whole Car.

THE greatest advantage of any motor vehicle, whether it be intended for pleasure or commercial use, is its appearance. This is usually given considerable study when the car is purchased; however, the value of appearance is soon lost sight of, and in six to eight months the car is ready for another painting or refinishing. Considerable attention is generally directed to the adjusting of the mechanism, but very little attention is paid to the finish. Reference is not only made to the body, but also to the motor, radiator, the chassis in general, upholstering and top.

The clean cut motor of the present day with all working parts enclosed requires but a few minutes a week with a little waste and kerosene or gasoline. Applying the waste, saturated with either of these will remove all oil, grease and dirt. The oil and grease soon become covered with dust and will cake and harden.

The mud pan should be thoroughly cleansed, so that all oil and gasoline are removed, as this is the cause of a considerable number of fires, when the motor backfires through the carburetor, and especially when it is mounted low so that the flame shoots under the motor. The inner side of the hood should also be cleansed regularly, as this usually catches oil thrown off the motor.

The radiator air spaces are often clogged with

mud from the road, which should be washed off. If it is permitted to remain it will eventually reduce the efficiency of the cooling system, by retarding the air circulation through the radiator. The transmission, inner side of the frame, brackets, control levers, pedals, etc., should be kept clean, as grit and sand in these bearings will cause wear to appear rapidly.

Kerosene is frequently used for cleaning out the disc, clutch and lower half of the crank case. This should be saved, as it lends itself well to the cleaning of all metal parts. After cleaning, all metal parts should be rubbed dry and all bright parts should be polished.

Spare rims and tires should be kept clean and covered, so that they can be handled quickly and comfortably.

The fenders add considerable to the appearance of the car and should always be kept in proper condition. Mud should never be removed with tools after it has become hard. If it is too heavy to wash off a wood mallet faced with about twenty-four thicknesses of flannel should be used, so that the finish will not be marred by blows from the mallet.

Mud contains substances undergoing chemical action that tends to corrode and dull the enamel or varnish when allowed to remain for any considerable length of time.

Turning now to the body, which, perhaps, gets some attention, it may be well to enlighten the lay man on the care necessary in preserving the luster. Among the necessities for successfully accomplishing this are two sets of each, pails, sponges, chamois and, in fact, everything connected with the washing of a car. The above articles for the first washing should be kept separate from those used for the second washing. A further suggestion would be to use separate

sponges and chamois for the chassis and wheels, as more or less grease and oil collects on these parts, which should not reach the body. Oil gives the body a cloudy and smeared appearance, while mud which hardens leaves a spotted surface, which can only be remedied by refinishing. Never allow any one to rub their hands on any of the varnished parts of the car, as the fine particles of dust under the fingers will scratch the varnish lik emery.

The water should be applied to the body with a hose, using it without a nozzle or a soft wool sponge. When the mud has caked very hard allow it to soak a little by playing the stream on it. An easy flow of water through the hose will soften the heavy coating, which is all that is necessary. Don't squirt the water from a nozzle of the hose against the car, but rather let it run freely with a slight pressure, thus washing it away as freely as possible.

Following this a solution of soap dissolved in lukewarm water should be used to remove the remaining dirt with a soft sponge. Care should be taken to keep the sponge clean, removing the sand and grit frequently, as it will accumulate very rapidly and scratch the surface. A good soap is of considerable assistance, but be careful that it is strictly neutral, as a soap which contains an excess of alkali or oil is injurious to the varnish. The surface should be thoroughly cleansed, leaving no trace of mud or grit. Then rinse off the soap solution with a soft sponge and a good quantity of fresh water before it has had time to dry. The next step is to dry the surface with a chamois skin, rubbing it only lightly. It should be wiped lightly over the surface, leaving a thin vapor on the body, which drys quickly, leaving the surface clean and sparkling. Rinse the chamois frequently and wring dry.

In washing the car always be careful not to let water reach the batteries, spark coil, or any unit of ignition, starting and lighting units. Particular attention should be given to the corners and crevices, and water which may lodge there should be soaked up with a sponge and well dried.

Gasoline or turpentine should not be used in cleaning paint work on the car; while bright sunlight will not only crack the varnish, but will deaden the gloss of the best finish. In dusting varnished surfaces always use a soft woolen duster rather than one made of feathers.

The leather upholstering can be cleansed by washing with lukewarm water and castile soap, then rinsing with clear water, using a sponge in both operations. The surface then should be wiped dry with a piece of soft woolen cloth after which a good leather dressing can be applied. Don't attempt to clean leather trimmings with gasoline, stick to the soap and water.

Glass fronts and windows can be cleaned by first wetting them over with a soft piece of sponge moistened slightly with denatured alcohol diluted to about one-third its original strength in water and dipped slightly into pumice stone flour. Allow this mixture to dry, then wipe off with dry cloth and polish with tissue paper.

Perhaps the most neglected part of a motor car is the top. This plays an important part in the economy of the car and should receive its share of attention.

The top should be cleaned by first putting a little castile soap in a bucket of tepid water until a good suds is obtained; then wet a soft wool sponge in this solution and wash the top, using water plentiful enough to start the dirt. Then go over the top with clean, soft water to catch up the traces of alkali, finishing up with a chamois skin to dry off. Now apply sparingly any selected

top dressing of reliable quality. Never fold the top back until thoroughly dry.

Grinding the Valves.

There is a right and a wrong way of performing so simple an operation as grinding valves, and often mortorists make a muss of their engine because they fail in performing this simple operation. Very few think of examining the valve stem while they have the valves out of the cylinder, as the chances are that their stems are coated with dirt and carbonized oil and possibly the stem has been binding in its guide. If it is allowed to go back in this condition, one of two things will happen. Either the stem will grind out the valve guide or it will bind up and cause a broken timing gear. While the valve is out it should be thoroughly examined and all grit and carbon removed, while it should also be tested for trueness in the stem, as it may have been burnt. Often one will diligently grind a badly pitted valve for an hour or so, and replace it without verifying its clearance over the tappet. Always verify this clearance in replacing the valve. Also be sure to examine the valve and its stem for cracks or defects, as a broken valve is very apt to cause serious damage.

After a careful examination of each valve we can proceed to grind in the valves. First plug the opening into the valve with some waste or wadding so that no grinding compound can get into the cylinder. If these abrasives do get into the cylinder, they will grind the piston, cylinder, and score parts which are supposed to have had all the grinding they need before they left their birthplace. Next in order is to use the finest grinding compound that it is possible to secure, known as carborundum. Mix this with a little oil to form a paste and rub it on the valve seat, not

too thickly. A brace and screwdriver bit makes a handy tool; however, a screwdriver will suffice if the former is not at hand.

Now, don't spin the valve around as though you were out for a record of revolutions, but rather give it about a half-dozen turns under pressure and then lift it up and turn the valve around, to avoid ringing. If you do not change the position of the valve on its seat it will make a bright appearance all around on the valve, but generally leaves the seat in poor condition.

A light spring if placed under the valve will raise it from its seat as soon as the pressure is released. Another good method is to use a screwdriver or brace and an oscillating movement to grind the valve; that is, turn first in one direction, say for four or five revolutions, then lift the valve from its seat and repeat the operation in the opposite direction. Keep this up until the whole contact surface of the valve and its seat are polished silver-bright; no black spots should be permitted, as these points will permit gas to escape. Both valve and seat should show a bright circle about 1/16-in. wide around the conical surfaces. It is not necessary to have a wide seat, since this is of no more benefit than a narrow one which is ground properly.

Another important job comes at the finish, as every particle of grinding compound must be removed from the valve chamber, valve parts and valve guide, as this compound will easily score the cylinder and other parts.

Wash it out thoroughly with gasoline or kerosene and reassemble engine; while doing this it is a good idea to check over the valve timing of the engine.

Vibration And Radiators.

It is not an uncommon occurrence after taking a leaky radiator to the expert for repairs that after replacing it on the car it develops another leak. Generally the motorist comes to the conclusion that the workman was at fault. This is not always true, for it is not the repaired leaks that give trouble, but the new ones developed. Much of the reported radiator troubles are due to the method of suspension.

The more recent types of cars have the radiators so mounted that frame stresses are not transmitted to the radiator, and provision is also made for eliminating vibration. On old cars the road shocks are transmitted to the radiator, which with the frame stresses impair its efficiency. Before replacing an old radiator, and especially if it rests on a cross member of the frame, fit a strip of rubber or similar material to provide a cushion and to absorb shocks.

Cure for Rattling Doors.

Rattling doors are very annoying and this trouble is not always confined to the low-priced motor car. A simple remedy is to pad out the hinges or catches with thin rubber sheeting. If the doors jam, graphite their engaging faces or file down the high spots. The cause of the doors seizing is generally due to the body settling.

Nut Locking Methods.

A lock nut or washer is generally employed to maintain the tightness of a nut or bolt but frequently there is not room for these members. Moistening the nut and screw and allowing the parts to rust will render the nut secure, or a coat of quick-drying paint will often serve the same purpose.

Cleaning the Muffler.

A dirty or clogged muffler will materially affect the output of the motor, as considerable back pressure will be developed. A simple method of cleaning the muffler without removing and disassembling it, is to take a wooden mallet and tap the exterior smartly. This will loosen the greater part of the deposits, which will be blown out when the motor is started. It will be surprising the amount of soot that can be removed from a muffler.

Hints.

Let it not be forgotten that kerosene is one of the best agents obtainable for cleaning the metal parts of the car, as it cuts the grease even better than gasoline, and is not so likely to ignite if exposed to the flame of a blow torch or a carelessly-handled match. It is best to dry the kerosene off the metal after it is clean, and this should be accomplished by a careful wiping with a cloth or bit of waste.

By cutting out a square in the floor of the tonneau and attaching a proper sized box underneath, you can have a very convenient carrying receptacle in space that is not otherwise taken up. It makes a good place to put a carbon footwarmer in winter, and may be used for tools and jack at other times.

Remember that new tires carried on the car, if not protected from the sunlight, will quickly oxidize, crack and become quite worthless. A new tire should preferably be put into service a little while now and then. It will not then deteriorate near so quickly. It is better, however, to have a cover for extra tires.

Gasoline Pipe Repairs.

It is always well to carry a section of rubber tubing with which to make a temporary repair should a pipe break on the road. If the gasoline pipe breaks off short at the union a gas-tight repair can be made by filing the end of the pipe to a cone shape, so that it may be forced into the seating. Next slip over it a piece of rubber tubing, and when the union nut is tightened it expands the rubber inside the union into a form of washer, which will make a perfectly tight temporary job. An additional precaution may be taken by applying a touch of soap around the union at the place where the pipe enters and also on the thread.

Fly-Wheel Knock.

It sometimes happens that the bolts securing the fly-wheel to the flange on the crank shaft work a trifle loose, and, as a result, there comes an irregular knock, hard to distinguish from a loose connecting rod big end. This fly-wheel knock will be more noticeable at slow motor speeds, or when the engine is being accelerated or retarded. This is worth remembering when an obscure knock puzzles you to diagnose.

Careful of New Car.

It requires some self-restraint to forego the pleasure of operating a new car as soon as received, but this should not be done unless the machine has been driven from a responsible agent who guarantees that it is ready for the road. Even then the wise motorist takes a careful look over the car, paying particular attention to the oiling system, the amount of water in the radiator and gasoline in the tank and the adjustment of the brakes. Frequently such an inspection will disclose a lack of oil, water or a slipping brake that might result seriously on the road.

Care of Garage Floors.

Concrete floors in garages should be painted with a preparation giving them a smooth surface which is easily cleaned and saves the concrete from wear and gritty dust from rising. The floors should be pitched slightly from the center line down to the side walls, both ways, with gutters formed in the concrete along the walls so that washing may be done, if necessary, without moving the cars.

Storage Battery Trouble.

Derangements in a storage battery may be caused through the electrolyte becoming low, completely or partially destroyed or not of proper specific gravity; the plates may be sulphated, there may be sediment in the bottom causing short circuits of the plates, terminals may be corroded, or there may be loose wires or connectors. It is often wise to look at the wiring, as there may be defective insulation, wire broken inside of outer coverings, oil soaked or chafed insulation which always cause short circuiting wherever the wire comes in contact with metal.

Replacing Spark Plug Nut.

To render easier the replacement of the tiny nuts that hold ignition cables to spark plugs, it is a good plan to remove the top three or four threads with a file; if this is done, the nuts can be put on, even with gloves, merely by dropping them in place and giving them a twirl. Do not tighten too tight as you may turn the wire through the porcelain and change the spark gap.

Loss of Motor Power—Its Cause.

When there is loss of power and yet the engine is firing regularly but weak, look for loss of com-

pression at either valves or spark plugs. Of course, this may also be due to the trembler on the coil vibrating too slowly, and this can be obviated by readjusting and trimming the platinum points. Then, again, it may be due to too rich a mixture or flooding of the carburetor. Sometimes the extra air valve on the carburetor refuses to work, and again it may be caused by faulty lubrication. Look for weak springs on the inlet valves, the lift of the exhaust may be reduced or the silencer outlets choaked with dirt carbon or charred oil.

Causes of Ignition Trouble.

Ignition trouble in a car fitted with a high tension magneto may be due to dirty oil, metallic particles or carbon in the distributor; the brushes may not be in contact or the breaker points out of adjustment, worn, dirty or pitted. There may be defective winding, the field magnets weak, the magneto driving gear loose or the magneto out of time.

Bright headlights are absolutely necessary for safe driving at night, but when two cars meet in the night on a narrow road, with headlights dazzling each driver's eyes, great care should be used. There is danger from obstacles on the sides of the roadway and danger from wrong estimate of distance between the cars. To be safe slow down and dim your lights before meeting the approaching car.

The filler cap should be replaced and care taken that the small hole in the center of the cap is open so that air may be admitted as the fuel is used. This prevents the pressure within the tank becoming less than that of the atmosphere.

Care of Radiator.

The radiator should be filled with clean water. As with the fuel, the same care should be taken with the water, to see that it is free from any foreign matter; the latter may clog the restricted passages of the radiator and impair its efficiency.

Because an electric motor or dynamo is completely enclosed, so that it is impossible for dust and dirt to work in from the outside, it does not follow that the interior will be free from dust. On the contrary, the gradual wear of the brushes and the slower wear of the commutator produce a dust that is more or less abrasive and also is a good conductor of electricity.

Spark plug adjustment will clear up magneto troubles, nine times out of ten. If the points on the plugs are adjusted right the gap will be such that the current can readily jump the gaps and ignite the charge. Often the car will run all right on the battery and yet when switched onto the magneto there is trouble, and the blame is laid onto the magneto, when a mere changing of the spark plug gap is all that is needed. Some magneto manufacturers provide a fine gauge for spark plug gaps, while others advise a gap varying from one-fortieth to a sixty-fourth of an inch. Many use a worn thin ten-cent piece as a gauge, but the best way is to experiment around these figures until the proper gap has been effected, and then always keep the gaps at this figure. It is important, however, to make sure that the gap on all four plugs is uniform, otherwise the motor will work with a jerk.

It often happens that the enamel on the hood becomes blistered from the exhaust pipe. An asbestos shield fitted inside the hood and about an inch from it, will prevent this most unsightly

trouble. Two arms should be secured onto the inside of the hood at the strategic position and to these a sheet of asbestos is attached. A similar attachment will prevent the exhaust pipe charring the woodwork of the dash.

After filling the radiator it is advisable to turn the engine over several times to allow the water to circulate through the cooling system and any air pockets that may have formed; this will be indicated by a lowering of the water level in the radiator, in which case more water should be added. If the car be driven in winter, a good non-freezing solution should be used.

It is often necessary for the motor car owner who does his own repairing to hammer a polished surface, which would be absolutely ruined by a steel or wooden hammer. Rubber mallets can be bought for just this sort of work at almost any supply store, or at a pinch a pad may be made from several thicknesses of old rubber, which will prevent marring the polished surface.

When preparing for a long run the gasoline, oil and water should be tested. The amount of fuel and water in the tanks and radiators may be determined in some automobiles by glass gauge tubes fixed to the fuel and water tanks showing the level of the liquids at a glance. In others it is a simple matter to test the level by inserting a stick in the filling hole and noting the height to which the liquid rises on it; the fuel level may be tested in this way if the stick be withdrawn quickly and examined before evaporation takes place.

Gasoline should be strained to guard against the carburetor passages becoming clogged by foreign matter that may be contained in the fuel. A chamois skin or wire netting having a very fine mesh may be used as a filter.

Racing the Motor.

While there is reason in abundance for running a motor, without load, at reasonably high speed for the purpose of making carburetor adjustments and the like, there is no excuse for "opening her up wide" and letting "her" turn up to the last limit of speed. Under no conceivable practical conditions could the motor run in such a way in service, and there is little sense in forcing a motor to do things that are absolutely useless merely for the purpose of making a fearful noise—which is the most obvious result. Further, excessive racing must be productive of a certain amount of wear and tear and no small unnecessary strain due to the tremendous centrifugal force exerted by the rotating parts and it is to the interest of the car owner to avoid whatever is unnecessary of this sort. Tuning a carburetor so that it will carry the motor at 3,000 revolutions per minute when it cannot pull the car when running over 1,700 revolutions is nothing short of foolishness, though it often goes to the extent of being a nuisance.

Fan Belt.

During the hot months the motor requires all the cooling available. The fan-belt is an important part of the cooling system, and attention in the shape of examining same to see that it is not slipping is advisable. If the belt is removed and thoroughly cleaned with gasoline, then allowed to soak a few hours in castor oil, this will refresh its gripping powers and will make the oldest belt new.

Leaky Spark Plugs.

Leaky plugs can cause a lot of trouble that is very difficult to trace. They will make a motor miss at high speed or on heavy pulls, but will per-

mit it to run quite properly, to all intents and purposes, under ordinary conditions. The principal trouble is cracked or porous porcelains, which allow the high-tension current to ground without jumping the spark gaps. The only remedy is to fit new plugs that are known to be in good condition, and to be careful not to crack the porcelain in tightening them in the cylinders. Never screw a cold plug tightly into a hot cylinder.

Valves.

Anything that tends to push a valve to one side, or lift it by applying force in any way except centrally, is likely to cause unequal and abnormal wear of both stem and seating. For this reason the end of the stem and the top of the lifter or tappet should be true and square and make perfectly even contact, which cannot be done if either is unevenly worn. This is a matter that often has made trouble and it has been ascribed to other causes.

Battery.

The positive pole of batteries are usually marked (+). It may also be determined by the chocolate color of the plate. The negative pole is often recognized by mark (—). When a battery is to remain idle it should either be charged and filled with water or charged and recharged at least once a month. By standing it will deteriorate.

Cleaning Ball Check Valves in Oil Pump.

The ball check valves which control the movement of oil through the pump where pressure feed lubrication is adhered to, should be cleaned occasionally to insure proper working.

Polishing Valves.

A practice that is said by some repair men to be beneficial is that of putting a sort of final polish

on valves, after grinding, with graphite. After the grinding has been completed and all the oil and grinding compound thoroughly washed off the valve seat is sprinkled well with dry graphite and the valve is worked on its seat just as in grinding. The result is said to be that the surfaces resist wear longer and retain their tightness better than without the graphite finish.

The Care of Rims.

The care of rims is important. They should be kept free of rust by the liberal use of sandpaper, and it is well to remove the tire and paint them with graphite occasionally. Ordinary stove polish is an excellent rim preserver. If the rims are bent or roughened, rim-cutting will result. These conditions should be remedied at once. The bolts or rivets fastening the rim to felloe sometimes work loose and project sufficiently to injure the tube. This can be corrected with a file.

Compression Leakage.

Compression leakage past the valves of a motor may be due to a great variety of causes. The valves may warp, due to the use of inferior material in their manufacture, or to faulty cooling of the valve chamber. This latter may be brought about suddenly by an obstruction in the jacket around the valve. Excessive grinding of the valve will reduce the clearances between the stem and cam, so that the member cannot close completely. This will be noticed immediately after grinding, and the remedy is to take enough off the stem to obtain the proper clearance. Deposits of carbon on the valve seat will also hold the valve off it and allow the compression to escape.

Leaky Inner Tube.

There is nothing much more mysterious or baffling than a tire which gradually loses its air, though it is positively known that the tube does not leak and that the valve is in good shape. But there is always a reason for such things, and one reason for loss of air may be that the pin in the tire valve is a trifle too long, so that when the cap is screwed on it makes contact with the pin and pushes the valve off its seat. Filing a little off the end of the pin is all that is necessary to end the loss of air.

Heating, Ventilating, a Touring Car.

A touring car may be warmed in winter with very little trouble, if it be fitted with storm curtains that can be drawn sufficiently tight to exclude most of the outside air. If this is the case, fit a large ventilator in the dash to allow the warm air from the motor and radiator to enter. A pipe may be tapped into the exhaust manifold and led through the radiator in the tonneau, exhausting into the open air.

Lamp Reflectors.

In order to prevent the silvering of lamp reflectors from tarnishing when not in use, it is a good scheme to give the surfaces a light coating of alcohol in which a little collodion has been dissolved. This will form an excellent protection, and is easily washed off with warm water. Of course, any polished metal surface can be protected in the same way.

Engine Used As Brake.

When using the engine as a brake in descending hills with the ignition cut off, open the throttle. This will materially cool and clean the

cylinders, while if the throttle be closed a certain amount of oil will be sucked into the cylinders from the crank case.

Ball Bearings.

Worn or broken ball bearings should be replaced with an entirely new set, as one or two new balls will always be just a trifle larger than the worn ones thus taking the load.

Hand Motor Primers.

It sometimes happens that the motor has to be primed on the road, and there is nothing at hand with which to take the necessary gasoline from the tank.

A good way is to take a tire valve dust cap and lower it into the tank by means of a piece of string. One capful to each cylinder should be about the right quantity of gasoline to use.

Oil On the Motor.

Oil on a motor is a most prolific dirt catcher, and dirt has no place about the automobile. If it hangs in masses outside, it is apt to get inside on the slightest opportunity, as in fitting in a new spark plug. Besides, it does not look well. Occasionally a driver will find one side of the motor dripping with oil; mysteriously appearing from nowhere, and especially plentiful after a hard run. The oil probably has been splashed up through the crank case breather. If the case has not been filled too full of oil, a brass tube carrying three baffle plates should be fitted inside the breather. This will stop the splashing out.

Carrying Extra Tubes and Casings.

Extra tubes should be folded and wrapped in cloth or put in a cloth bag. If left in the original cartons or thrown loosely under the seat, they will chafe at points of contact. Never put them

in the tool box or where they will come in contact with chains, tools or grease.

Spare cases should be provided with covers. The wind and sun dry them out and damp getting inside rots the fabric. Interchange your tires occasionally, for rubber deteriorates faster out of use than in. Remember it is no economy to carry retreaded or repaired cases as extras. Having been through a second heat of vulcanization they are liable to more rapid deterioration than new cases, but if put in service immediately, you will get full service out of them before this can have much effect.

Carbon.

Carbon trouble is one of the recurring annoyances of automobile motors which never has been entirely removed. The heat of combustion is so high that even the best of oils leave some deposit. This may be so small that it is not noticeable after an entire season's use, but, on the other hand, it might be so great that the motor refuses to function as it should. When going over the car it would be best to thoroughly clean the cylinders of all traces of carbon.

How To Hold Steering Wheel.

To properly hold the steering wheel, let the right hand firmly grasp the rim just below the horizontal center with the forearm describing a right angle; the left hand should be just below the right in the same sectional space. The method is employed by racing drivers.

Bricks and Rocks.

On hills drivers of heavy vehicles often use large stones, bricks, etc., for holding their vehicle when they are forced to halt because of the steep incline. When they start off they invariably leave

such stones, rocks, etc., lay on the highway. Many springs are broken, tires either blown out or causing the beginning of a blowout from driving over such bricks, etc. Watch for these obstructions on hills.

How to Make a Fire Extinguisher.

An automatic fire extinguisher may be made by dissolving three pounds of salt and one-half pound of sal ammoniac in one gallon of water. Suspend over a gasoline tank by a string and in a bottle that will break readily. Bottle must be high enough to break in the falling. When gasoline catches fire, the string will burn and the bottle will fall and break.

Interchangeable Tires.

If your tires habitually give low mileage, try an oversize. These will increase the cross-section of your air cushion, as well as giving a heavier and more wear-resisting tread, and if your tires have been overloaded, will overcome the trouble. Besides, there will be added comfort in riding and less wear and tear on the engine, by reason of decreased shock and vibration.

Piston Ring.

Should a piston ring be worn to the extent that it would cause loss of compression you can temporarily restore compression and its expanding properties by placing a small piece of clock spring behind the defective ring. Place the clock spring in the groove and be cautious that it is of the proper size to fit in the groove.

Adjustment for a New Spark Plug.

Don't fail to slightly tighten up all the parts of the spark plug after it has been used for the first time. Most manufacturers ship plugs with the brass bushings slightly loose to allow for the ex-

pansion of the metal parts from heat. This eliminates the possibility of cracking the porcelain when the plug is first used.

Magneto Cover.

It is important that magnetos be protected with a cover against dust as well as moisture. A certain amount of dust is always entering through the radiator and with the assistance of the fan is blown around the motor. The dust clinging to certain parts of the magneto will retain moisture and impair the ignition.

Emergency Repairs.

An invaluable accessory is an Inside Protection Patch and outside Emergency Band. These can be separately used, but should always be used together if possible, as otherwise the original injury will spread and make an ultimate repair either impossible or more costly.

Tires Heating.

The heating of the tire is the first direct result of the frictional action between the outer shoe and the inner tube. This can to a certain degree be avoided by rubbing French chalk over the inner tube before inserting it.

Rule of the Road.

Remember the rule of the road and don't drive on the wrong side. Should an accident occur while driving on the wrong side, whosoever was on the wrong side must pay the damages. It is a violation of the law.

Locating Squeaks.

Squeaks are sometimes a hazardous undertaking to locate. A body resting on the frame unevenly will in most instances cause a cracking sound. By placing strips of leather between body

and frame (preferably where body bolts pass through frame) this often overcomes this noise. A rubbing or rattling noise can most frequently be attributed to the edges of doors rubbing against their frames. This is often the result of the body sagging in the center and can be remedied by placing a shim of the required thickness under body bolt on the side where the door rattles. It sometimes happens that a door will bind or stick; this is due from practically the same cause. In the latter instance, however, the body may be shimed too high on either side, and by removing a certain amount of shiming it may overcome the trouble.

Another annoying noise which often occurs is a sharp, dry squeak coming from spring shackle bolts, brake rod, cleves, pins, steering cross tube connections, etc. Many owners and drivers become discouraged in their attempts to obliterate such squeaks. Examine oilers or grease cups attached to spring bolts, etc., to determine that same have free passage. Probably some of the above connections are too tight or paint may be keeping the lubricant from reaching the vital points. Squirt a superfluous amount of oil around all moving parts. See that brakes are released completely and free from dragging.

Hard Rubber Repairs, Etc.

The hard rubber in storage battery jars is of excellent quality, and pieces from broken jars therefore are frequently of use in making repairs or doing work in which good, strong insulating material is needed.

Dry Cell Bolts.

It is a common scene to notice many of the little brass bolts used on dry cells lying around garages, etc. They should be saved, as they often

make useful fastenings for many places where rivets and screws are used.

Encourage your car's ability by careful handling.

A thin coat of ordinary grease applied between the body and frame will remedy certain body squeaks.

An examination of all steering connections occasionally is time well spent.

Expenses can be greatly reduced by regular oiling and examination of parts.

Marking Front Gears.

While most all factories adopt a standard scale of marking the front gears (consisting chiefly of crank shaft and cam shaft gears), it occurs sometimes where it is necessary to move a gear ahead or behind one or more teeth to attain the proper timing. Should you remove any such gears and do not understand thoroughly the method of timing a motor it would result in improper timing and possible loss of power or cause the motor to knock. You can avoid such difficulties when disassembling any of the front gears by marking the gear and shaft with a center punch; also mark the gears where they mesh while in the same position. In assembling note that your marks correspond, which will be the same setting previous to removing the gears.

Short Circuiting, Wire Breaks.

Ignition derangements are often due to the insulation of the spark plugs being cracked or oil soaked. Then again there may be carbon or oil deposits or the points too close together or too far apart. The electrodes may be broken through using too much force and too heavy a wrench. Look over the plug carefully and test

for all these things. Incidentally, don't forget to take a peek at the timer. The contacts may be worn or pitted, there may be dirty oil or particles of metallic matter, shoulders on the segments, worn bearings, loose or broken wires causing a short circuit. When your engine stops suddenly on the road it may be due to a score of things, and it will always pay to look after the following first. It is generally due to lack of gasoline. If not, you will find some failure of the ignition service, failure on the spark, electric circuit disconnected, broken or loose wire, terminal loose on the coil, storage battery, contact maker, switch or spark plug, break or chafe on the wiring under the insulation, or some magneto defect.

Sometimes, among other unheard of things, a wire breaks inside of its insulation and gives no exterior sign of the break. This may cause all sorts of trouble and very often the blame is laid at the door of the ignition department. Spark plugs are changed and magnetos pulled down, so that it is a good thing before taking everything else to pieces to make sure that there are no interior breaks in the insulation cable.

Electric Lamp Bulbs.

If the electric lamp in your head, dash, or tail light burns with reddish color instead of the pure white that it did when you first put it in, it is played out, and it is time to replace it with a new bulb. This should be done, not only to give a better light, but to save money, as the lamp is consuming more electric current and giving less light. Unless the lamp is one of the Tungsten or Tantalum types, you must not expect more than 600 hours' service out of it. This will surprise a good many people who think an electric

light bulb is good for a lifetime. The filaments of the electric lamp are like the wick of a kerosene lamp, they become charred and finally burn away, and must be replaced, but, of course, after a much longer use. So if you want good lights with a moderate amount of current consumed, watch your lamps carefully and replace when the red color appears and be sure your lattery is fully charged.

How to Distinguish Direct from Alternating Current.

Direct and alternating current seem to puzzle a great many people. To find out which is which one has to ask some one better informed or set about to educate yourself how to tell the difference, and the following simple way is open to every one. Hold a simple magnet bar near a lighted incandescent lamp; if the current is alternating the filament, that is, the part inside the lamp from which the light emanates, will vibrate; if the current is direct the filament will be attracted or repelled as the positive or the negative pole of the magnet is held near the lamp.

Hose Connection.

You can make a secure hose connection to gas headlights, or water connection by first wrapping a small piece of tape around rubber hose, then draw up with a piece of wire. By placing the tape around the hose it will prevent the wire from cutting through the rubber hose.

Drilling.

When drilling a small piece of work you can keep same from turning by placing a stiff piece of emery cloth between piece of work you are drilling and table of drill press.

Laying Up Your Car, or Putting It Into Commission Again.

Before laying up your car for a period, jack it up clear of the floor, allowing the axles to rest on supports. Allow all air to escape from the tires, except enough to shape them, and then examine tires and rims carefully.

If tires are practically new or in good repair, and rims in good shape, it will be all right to leave them on the car. Be sure to remove all oil and grease from the tires. Wash them with good strong soap and water. If the rubber is cut to the fabric, be sure to have the injury repaired before using the car again.

Whether or not the tires remain on the car during a prolonged period of idleness, they should be wrapped to exclude the light and should be kept in a cool room.

Oil and the Commutator.

Thinner oil must be used for the commutator in the timer than any other part of the car, as the slightest gumminess will cause a tendency to skip or miss. About every thousand miles the timer should be taken apart and thoroughly cleaned, the process including wiping out the race, fiber, contact points and all, in order to remove collections of thickened oil and dust. If the oil has a tendency to gum excessively, kerosene may be used to thin it out. The correct proportion is about 25 per cent of kerosene. In cold weather especially this is of value.

Cleaning a Spark Plug.

If you want to thoroughly clean a dirty, sooty spark plug, soak it over night in alcohol. Another good and quick way is to insert the plug in the ground, terminal point down, and fill the shell carefully with gasoline and ignite with a match. When the gasoline is burned out the plug will be found to be almost entirely cleaned of soot.

CHAPTER XXV.

A Few Hints to the Tourist.

SOME of the following will be helpful for the tourist before starting on an extended trip:

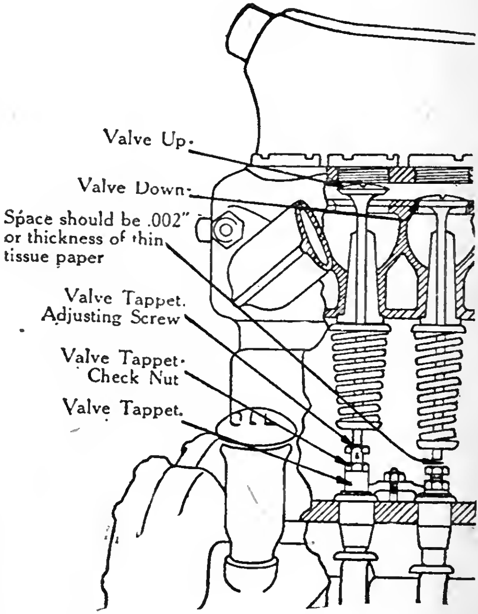
The Motor.

Your engine should be in proper trim and everything should be gone over carefully. Oil should be changed about every 1000 miles. Examine motor bearings to discover whether there is too much play in connecting rod brasses (bushings). Place the crank on the bottom dead center, take hold of the connecting rod and try lifting it up and down. Should there be 1/64 inch play they should be taken up by removing shims of equal thickness from each side of bearing or by laying a smooth file on the bench the brasses or liners can be rubbed over same and reduced until the connecting rod bearing is again fitted properly. After each rod is fitted the motor should be turned over by hand to feel for any binding. Should too much be filed off the brasses, place either a thin piece of tin, zinc or brass under the brasses.

Valves.

You can determine the compression of each individual cylinder by opening all relief cocks excepting one. Turn motor over by hand until you buck compression, which will indicate you are trying the compression on the particular cylinder with the relief cock closed. By continuously rocking motor against compression a few times with crank handle the compression will either buck consistently or gradually loose. In the latter instance the loss of compression is due in all prob-

abilities because the valves are seating improperly. Example: Close all cylinder relief cocks excepting No. 1. After having tried No. 1 cylinder, open same and close relief cock No. 2 cylinder, and so on, vice versa. Before grinding valves examine same to see if they are pitted, in which



An illustrated lesson in valve adjusting.

case a slight cut taken off in a lathe will save much time. A valve need not necessarily show a bearing all over the valve seating; however, it is not properly ground until it shows a contact all around the valve. When finished grinding adjust properly.

Attention should be given the opening and closing of valves, which will also cause a loss of compression and power.

Ignition.

Follow all wires starting from battery box and leading to switch, also magneto to spark-plug wires, and examine carefully for loose terminals, or possibly a wire has loosened and by rubbing on some moving part worn through the insulation, causing a leakage of juice. Poor contacts on make-and-break contacts will cause misfiring. Good flat contacts are required and some attention in the shape of filing the platinum points on the make-and-break will remedy this trouble.

Steering Gear.

Examine with caution pins connecting on the steering arm, distance rod, and axle steering knuckle pins or bolts to determine whether same are all properly cotter pinned, greased and secure.

Transmission and Axles.

Starting from the front axle, detach all the wheels, remove all bearings, and after having washed off same in kerosene oil, as well as wheel spindle and inside of hubs, pack in a fresh supply of grease and attach again. Every time a wheel is removed the cup of the bearing is removed with it, and consequently the bearing must be properly adjusted when the wheel is replaced. The best method is to turn the bearing up tight, and then revolve the wheel a few times by hand, which overcomes any tendency to "back-lash."

Then back off the adjusting nut very slightly, so that by grasping the two spokes in a perdendicular line (one above and one below) you can begin to feel a very slight shake in the wheel. If this is more than barely perceptible, it is too

much, and the adjusting nut should be a little tighter. Do not overlook spindle body bolts. If they are loose, tighten them, because you will feel this looseness when you are adjusting the front wheel bearings.

When you have it just right, lock it, and the bearings will give you the best of service.

Gear bearings should be turned up to snug fit, but not so tight to prevent the gears from turning freely.

Attention should be given the transmission and rear axle as well as the universal joints. Remove drain plugs from the aforesaid parts and allow all old oil, grease, etc., to empty out. Your next step is to replace plugs again and jack up rear wheels about two inches clear of traction. Pour about one to one and one-half quarts of kerosene oil in transmission and rear axle, with about one-half pint in universal joints if same are encased. With this all in readiness, start up your motor and allow same to run about two minutes on low throttle. This will loosen small particles of oil and grease clinging to the housings of the different parts, as well as wash the bearings, etc. Remove drain plugs again to drain off this cleansing solution, after which you insert plugs and refill with a fresh supply of oil, grease, graphite, or any such lubricant as is recommended for the particular make car or part.

Spring Clips.

Manufacturers employ different methods in attaching spring clips. For instance, some are installed with a double lock nut, while others use the lock washer and nut; still, it often occurs that spring clips loosen sometimes, causing the breakage of spring leaves or even an entire spring.

It would be advisable to look over the spring clips once a month and see that nuts are tight.

Brakes.

With the car still on jacks, give your brakes some attention, and caution should be exercised if any adjustments are made to the extent that with brake being applied that braking powers will be equally effective to both wheels, unless brake connecting rods have an equalizer or some other such compensating device, in which case it will be unnecessary. If brakes are not equally adjusted on each side it will cause the car to skid to one side when they are applied.

In trying brakes to determine how they are holding, also if they are gripping both wheels equally, do not apply fully, but gradually. With the brake only partly applied, you try one wheel, then the other, and by gradually applying more brake you will notice in pulling on the wheels again just which side is out of adjustment. After having made the required adjustments to brakes, be sure to see that there is no binding or dragging by spinning the wheels a few times.

Spring Bolts, Grease Cups, Etc.

Manufacturers have provided a means to lubricate all moving parts wherever there is any friction or wear. However, some drivers and owners fail to regard seriously enough the value to be gained from regular oiling and greasing.

Spring bolts, radius rod support pins, brake connecting rod clevis pins, steering connections, and a few extra accessories, such as shock absorbers, speedometer, electric horn, etc., should be given daily attention. With a piece of waste and oil can, oil such parts as are supplied with oilers and give grease cups each one turn daily.

Tires, Tools, Accessories, Curtains for the Tour.

Having attended to the pointers mentioned in the preceding paragraphs, it now remains for the tourist to prepare for weather conditions, tires and the necessary tools to make minor repairs while on the road. With the top raised all curtains should be attached to assure they will fit properly to the buttons on top. Do not fold curtains; it cracks the celluloid and creases the cloth. Roll them to pack away.

It is advisable to replace badly worn casings and keep the older tires for emergency use. Inflate tires to proper pressure. With two extra casings, about four to five inner tubes, together with tire patches, fresh cement, chalk, about two blowout patches, and the tire equipment would appear complete. The tourist should next have a tool kit and be supplied with such tools as will enable him to make small roadside repairs.

The following can be used as a guide to help make up a tool kit. However, experience alone will in time dictate a complete outfit:

1 two-pound hammer.
1 small screw driver.
1 large screw driver,
1 No. 25 Double open end wrench.
1 No. 27 Double open end wrench.
1 No. 29 Double open end wrench.
1 No. 33 Double open end wrench.
1 Jack and handle
1 tire pump
1 complete tire repair kit.
1 oil-can
1 6-inch cold chisel with ½-inch face
1 12-inch monkey wrench.
1 14inch pipe wrench.
1 pair combination cutting plyers.
1 10-inch flat file
1 set tire tools.
1 12-inch hack saw and blade.
1 box assorted nuts and bolts.

1 box lock washers and cotter pins.
1 spool wire.
1 piece 2 feet insulated wire.
3 or 4 spark plugs.
1 6-inch drift.
1 canvas pail.
1 gallon lubricating oil.
1 gallon gasoline.

The tire tools should consist of the following

1 Jack
1 air-pump.
2 tire removers.

1 repair kit box, containing:

1 piece emery cloth, ½ dozen small patches.
1 tube cement, ½ dozen large patches.
2 valve tubes, ½ pound French chalk.
2 valve tube nuts.
3 valve plungers.

Anti-Freeze Solutions.

In order to prevent the water in the cooling system from freezing during the winter months when the motor is stopped, it is necessary to add some ingredients to this, and consequently, prevent the bursting of the radiator, cylinder, water packet, or some other unit of the cooling system.

The following mixture is recommended by a number of motor car makers, which will give satisfactory results:

For temperatures not lower than 5 degrees below zero—

Wood alcohol	15	per	cent
Glycerine	15	"	"
Water	70	"	"

For temperatures not lower than 15 degrees below zero—

Wood alcohol	17	per	cent
Glycerine	17	"	"
Water	66	"	"

The wood alcohol evaporates, and in order to maintain the proper proportions, small quantities of this should be added at intervals.